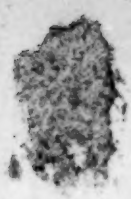

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE

Vol. X

JANUARY 1865 TO DECEMBER 1868

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PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. X. JANUARY, 1865. No. 73.

Stated Meeting, January 6, 1865.

Present, nine members.

Dr. WOOD, President, in the Chair.

Letters were read from the Natural History Society of Emden, the United States Coast Survey, and Mr. John Biddle, announcing donations for the Library.

Donations for the Library were received from Mr. John Biddle, of Philadelphia; Mr. Wm. S. Sullivant, of Ohio; the United States Treasury Department; the Royal Astronomical Society; the Director of the Mint, and Prof. Zantedeschi, of Padua.

A letter from Otto Struve, dated Pulkova, Dec. 1, 1864, announced the death of a member of the Society, F. G. W. Struve, at St. Petersburg, Nov. 11 (23), 1864, aged 71. Prof. Kendall was appointed to prepare an obituary notice of the deceased.

The decease of Hon. Geo. M. Dallas, at Philadelphia, Dec. 31, 1864, aged 72, was announced by Judge Sharswood, and on motion, Mr. J. R. Ingersoll was appointed to prepare an obituary notice of the deceased.

On motion, Judge Sharswood was excused from preparing an obituary notice of the late Samuel D. Ingham.

The report of the judges of the annual election of the Society, held this day, was read, and the following named officers were declared duly elected according to the laws, ordinances, and regulations of the Society for the ensuing year:

President.

George B. Wood.

Vice-Presidents.

John C. Cresson,
Isaac Lea,
George Sharswood.

Secretaries.

Charles B. Trego,
E. Otis Kendall,
John L. Le Conte,
J. P. Lesley.

Counsellors for Three Years

Isaac Hayes,
Robert E. Rogers,
H. C. Carey,
Robert Bridges.

Curators.

Franklin Peale,
Elias Durand,
Joseph Carson.

Treasurer.

Charles B. Trego.

Prof. Lesley was nominated Librarian for the ensuing year.

Pending nominations, Nos. 529, 530, 531, 532, 533, were read.

On motion of Dr. Coates, a special committee was appointed on the preparation of a medal for the Magellanic Premium, lately awarded, consisting of Dr. Coates, Dr. Wilcocks, and Mr. Peale.

On motion of Dr. Barnes, the thanks of the Society were ordered to be presented to Mr. John Biddle, for his valuable donation of Oriental books presented this evening.

Whereupon the Society was adjourned.

Stated Meeting, January 20, 1865.

Present, seventeen members.

Dr. Wood, President, in the Chair.

A letter was received from President Wayland, dated Providence, R. I., January 15, 1865, enclosing his photograph, and a donation of $5, towards the expenses of forwarding the Proceedings by mail.

The following letter was received from M. Troyon, dated Lausanne, November 10, 1864, communicating certain facts connected with a reopened Cemetery of the Merovingian era:

M. the Sec. of the Am. Phil. Soc., Philada.

Sir: I have the advantage of informing you of the reception of the Proceedings of the American Philosophical Society, Nos. 69, 70, which have just arrived, and for which I return my thanks.

Having the honor to be a member of your learned Society, you will permit me to say a few words respecting some excavations which I have made during the last few weeks, at my country seat of Bel-Air, near Lausanne, where I have already previously opened more than three hundred tombs of the Merovingian age. The tombs of this vast cemetery, which I discovered in 1838, are arranged in three stories (sout étagées en trois couches) or layers, beneath the surface of the soil. The most ancient is at a depth of five or six feet, while the highest layer is covered with only two feet of earth.

The superposition of the graves is not at all perfect, and it is easy for one to convince one's self that, after having filled once the consecrated space, they continued to inhume in the same cemetery, but at a little less depth, so as not to disturb the graves of the inferior layer, and finally recommenced for the third time the same operation. Some of the graves of the superior layer have also been reopened to place some new corpse, on which occasion the bones of the preoccupant have been swept *pêle mêle* into a corner, or into a pocket made to receive them.

The dead, stretched on their backs, were placed so as to have their eyes directed to the rising sun. A certain oscillation in the direction of the graves arose, without doubt, from the season at which the inhumation took place.

The construction is various enough. Sometimes the dead was simply deposited in a coffin of wood. Forty tombs have been cut in a bank of rock. The rest were constructed of rubble wall or with great rough flag-stones.

The ornaments gathered in this cemetery, and classified separately, according to the layer to which they belong, witness a sensible development of civilization from the fifth to the eighth centuries of our era, a period during which these inhumations have taken place on the hill of Bel-Air.

The warrior was accompanied by his arms, lance, arrow, and large cutlass, of iron. Great clasps (agrafs) and plates of iron, incrusted with silver, adorned the sword-belt. Sometimes a vase of glass or clay occupies the foot of the tomb. The child imports its playthings, and the woman her ornaments, necklaces of glassware or of enamel, knitting-needles (brochés), rings, and pins. The artisan preserves, also, the instruments of his profession. Many graves, however, contained nothing but a skeleton. The whole presents characters of present society, the rich and the poor; and it is to be remarked that the grave of the old man, accompanied by less regrets, is also furnished with fewer ornaments.

The Helveto-Burgundian population, whose tombs I discovered, professed Christianity, and left many signs symbolic of their faith; as, for instance, on the plates of bronze, the image of Christ blessing, of the prophet Daniel in the den of lions, or of a personage adoring the Cross, and turning the back on a fantastic figure, symbolizing the conversion of the heathen. On the other hand, the traces of the superstitions of the ancient worship are numerous enough. It is not rare to find fragments of glassware and pottery, which have

been deposited intentionally in the coffin. For a long time I could not comprehend their signification, but I have learned that identical deposits are sometimes still practised in certain Alpine valleys, with the feeling that it is a means of protecting the defunct from the attempts of the demon. Most of the tombs contain scattered embers taken from hearths, the traces of which subsist at under one or two feet of earth, around the circumference of the cemetery. As I have quite recently made the observation to M. le Baron de Duben, Professor of Anatomy at Stockholm, he has informed me that in our own day the inhabitants of Dalicarlia and Wermland still spread over the coffin of the departed burning coals, which they hide under their clothes in a little case (cassolette), but he is not able to inform me what signification they attach to it. I find, also, from time to time, flints, with steels (briquets), in allusion to the spark of life which should one day reanimate the remains; but other flints are lamellæ and arrow-heads, to which they evidently attributed the value of amulets, as the peasantry of many European countries do to-day, when they discover some of these fragments (pisées), which they carry under their clothes to keep off or cure certain maladies. I even possess in my collection an arrow-head of flint set in a heart of gold, bought a few years ago from a Scotch peasant.

Tombs of the kind of those at Bel-Air are found at numerous points in Western Switzerland, and it is to be remarked that we have just there the true ancestors of the present population. It is not, therefore, without interest, to determine that the general form of the crania of the Merovingian era was sensibly different from that which obtains now. The typical form then was generally elongated, with a decided posterior development, while the heads of our day are rounder, and have a greater frontal development. We see, then, the Christian civilization reacting on the development of the encephalon in one and the same people, the road upwards being always slower to travel than that of degradation.

Be pleased, M., to accept the expression of my most distinguished sentiments. Your devoted

FRED. TROYON.

LAUSANNE, November 10, 1864.

Donations for the Library were received from the Royal Astronomical and Geological Societies in London; the Essex, Albany, and Franklin Institutes; the American Antiquarian Society; the American Journal of Science and Arts;

Blanchard & Lea, and Dr. Slack, of Philadelphia; and the Architect of the Capitol at Washington. Allibone's Dictionary, Vol. I., and the Philadelphia Directory, for 1865, were purchased for the Library.

The death of Edward Everett, a member of the Society, at Boston, January 15, aged 70 years, 9 months, was announced by Mr. Fraley. It had already been announced to the Nation by the President of the United States.

A letter addressed to the President of the American Philosophical Society, and accompanied by a sealed envelope, was read, and referred to the Board of Officers and members of Council.

The committee to whom was referred Mr. T. P. James's paper, entitled "On new Mosses of the United States," reported in favor of its publication in the Transactions, which was so ordered.

Ten plates of MS. drawings of Tertiary leaves from the Tertiary beds of the *State of Mississippi*, by Mr. Lesquereux, of Columbus, Ohio, was offered by Mr. Ja ıes for publication in the Transactions, together with an estimate of the cost of drawing and printing made by Mr. Sinclair. On motion of Mr. James, the subject was referred to a committee, consisting of Messrs. James, Durand, Leidy, Carson, and Coates.

The committee to which was referred the subject of the Magellanic Premium and Medal, reported progress by its chairman, Dr. Coates.

On motion of Mr. Fraley, Mr. Lesley was appointed Librarian for the ensuing year.

The Standing Committees for the year were then appointed, viz.:

Committee on Finance.—Mr. Fraley, Mr. J. F. James, Mr. S. Powell.

Committee on Publication.—Dr. Bridges, Mr. T. P. James, Dr. Carson, Mr. Marsh, Dr. Wister.

Committee on Hall.—Mr. Peale, Prof. Coppée, Judge King.

Committee on Library.—Dr. Bell, Dr. Coates, Mr. Price, Mr. Barnes, Mr. Briggs.

The list of surviving members was read and corrected.

Pending nominations, Nos. 529 to 533, and new nomination, No. 534, were read.

Balloting for members then proceeded, and the following were announced by the President, duly elected members.

L'Abbé Ovide Brunet, Professor of Botany, Laval University, Quebec.

Prof. Goldwin Smith, University of Oxford, England.

Prof. A. Winchell, Geologist of the State of Michigan, Detroit.

Mr. Wm. E. Whitman, Attorney-at-law, Philadelphia.

Prof. Geo. J. Brush, Yale College, New Haven.

And the Society was adjourned.

Stated Meeting, February 3, 1865.

Present, fourteen members.

Dr. Wood, President, in the Chair.

Letters accepting membership were received from George J. Brush, dated New Haven, January 24, 1865, and from Ovide Brunet, dated Quebec, January 28, 1865; the latter giving the date of the death of Mr. Ross Cuthbert as September, 1861, and the former enclosing a photograph of the writer.

A letter declining the appointment to prepare an obituary notice of Mr. Dallas, was received from Mr. Ingersoll, dated January 23, 1865. On motion, Mr. Ingersoll was excused.

Donations for the Library were received from the Royal Saxon Society, Prof. Zantedeschi, the Royal Astronomical Society, Mr. E. Tucker, Editor of the Literary Gazette, and Dr. Marcet, of London; the Essex Institute, New Jersey Historical Society, Admiral Wilkes, and Mr. Snowdon, of Philadelphia.

The death of Dr. R. M. S. Jackson, at Chattanooga, January 18, 1865, aged 51, was announced by the Secretary.

The committee to which was referred the communication by Mr. Lesquereux, for the Transactions, recommended its publication, which was, on motion of Prof. Cresson, so ordered, and the committee discharged.

Mr. Briggs made a communication to the Society on the effects of impure air on human health, and the supposed necessity of aqueous vapor to a perfect system of hot air ventilation.* The subject was afterwards discussed by Prof. Cresson, Dr. Coates, who referred especially to the experiments of Dr. De La Roche with hot saturated air on animals, and Dr. Wilcocks.

Pending nominations, Nos. 524, 525, and 526, were read.

The committee appointed January 6, to report on the Magellanic Premium, reported progress.

And the Society was adjourned.

Stated Meeting, February 17, 1865.

Present, ten members.

Mr. PEALE in the Chair.

Letters accepting membership were received from Mr. Bost, dated La Force, January 23, 1865, and Prof. Winchell, dated Ann Arbor, January 30, 1865.

Letters of correspondence were received from the Russian Observatory, the N. H. S. Moscow, the Royal Academies at Stockholm and Leipsig, and the Royal Asiatic Society of Great Britain and Ireland.

Donations for the Library were received from the Russian Observatory, the Societies at Leipsig, Stockholm, and Haarlem, the Asylums at La Force, the Royal Astronomical,

* [See at the end of No. 73.—Sec. A. P. S.]

British Meteorological and Royal Geographical Societies, at London, the Edinburgh Observatory, Royal Irish Academy, and Prof. Houghton, the Boston Library, and Messrs. Blanchard & Lea.

The death of Capt. J. M. Gilliss, Superintendent of the United States Naval Observatory at Washington, February 19, 1865, aged about 55, was announced by Mr. Trego, and on motion of Mr. Fraley, Prof. Henry was appointed to prepare an obituary notice of the deceased.

The Secretary read a communication from Mr. Alexander Trippel, of Bethlehem, with drawings, illustrating Dr. Schinz's gas-generator for puddling and heating furnaces.

REHEATING FURNACE WITH GAS-HEATING FOR ANTHRACITE.

This furnace, which is represented in the accompanying plans, has the form and size of those in use at the Bethlehem Iron-works, with the exception of the fire-box, for which gas-generators are substituted, to convert the fuel into gas, previous to its combustion in the furnace.

The advantages of heating by gaseous fuel are now well known, and the system has been in actual operation ever since 1838, when, in Germany, Mr. Bishoff first used the tunnel-head gases of iron-blast furnaces.* Since then, the principle of converting fuel first into gas, before its application for heating bodies, has been variously extended and applied, especially for metallurgical operations, and here again more than for other purposes, for reheating and puddling furnaces. Nearly all sorts of fuel have been tried: charcoal, kiln-dried wood, peat, bituminous, and anthracite-like coals; and although success was not always fully achieved, enough was proved that the system offers considerable economy in fuel, and cleanliness of operation in the furnace, which, for some reasons, is of exceedingly great value. The want of success is, however, not due to the sys-

[* The invention of the use of the tunnel-head gases was decided in the celebrated lawsuit of the agent of Favre du Four v. the American Iron-masters, to belong to one of the Iron-masters of Pennsylvania, Mr. Bell, of Huntingdon County. See Iron Manufacturer's Guide, New York, 1858. Sec. A. P. S.]

tem; but in all cases of unsuccessfulness it could easily be proved, that the construction of the furnace had not been in accordance with facts, well and conclusively established by science, as well as practical experience, and was principally caused by a want of knowledge of the nature of fuel, and its chemical composition, the action of its component parts, when mixed with the oxygen contained in the atmospheric air, and the requisite conditions for a perfect combustion. From my own observation I can say, that the so called gas-furnaces have been constructed in such an irrational way, that success would have been either accidental or a miracle. Still, the possibility, or rather certainty, of making a much better use of, and obtaining a considerable higher useful effect from, fuel of all kinds, when first converted into gas, has occupied the minds of some of the most prominent men, and naturally more so in countries where the consumption of fuel is in excess of its production; and while some of the greatest savants have now proved conclusively that heat is equivalent to power, others have, in a more practical direction, tried to find the conditions necessary to obtain all the useful effect a fuel can furnish according to theory.

Foremost in these efforts has been Prof. Charles Shinz, editor of a large work on "The Application of Heat," and several other works treating similar subjects. Mr. Schinz, an eminent scholar in physics and chemistry, and gifted with an uncommon experience in many technical branches of industry, has shown that the most important conditions for a perfect combustion have mostly been overlooked; and, in comparing the effect of the hitherto best methods of heating with that which fuel ought and can give, he finds the following results:

Caloric Equivalent.

Fuel.	*Usual Method.*	*Gas-heating.*
Kiln-dried wood, . . .	2498 calorics.	3891 calorics.
Same, with 20 per cent. moisture,	1890 "	3006 "
Kiln-dried peat, . . .	3030 "	4574 "
Lignite (brown coal), . .	3651 "	5419 "
Bituminous coal, . . .	5228 "	7580 "
Anthracite, ...	5423 "	8034 "

It will be seen that the proportion of effect gives to the gas-heating method in all cases over 30 per cent., while comparisons with some old practised furnaces will show as much as 52 per cent. saving in fuel.

The most essential desiderata for a perfect combustion and the highest possible useful effect are, according to Mr. Schinz,

First. Stochiometric proportioning of air and gases.

Second. Sufficient contact surface between air and gas, and different velocities for each of them.

Third. Compression of the mixed gases and air at the moment of combustion.

Fourth. Some criterion, whereby to determine whether or not a perfect combustion takes place.

It is hardly necessary to mention that, in order to make these points, the chemical composition of the fuel must be well known; and that exact calculations have to be made with regard to all dimensions of the furnace. The rules and regulations by which to gain these results, and the peculiar construction of the furnace, form the chief points which distinguishes Mr. Schinz's system from others. His furnaces were rewarded with the prize medal in the late London Exhibition, and have since been patented in Europe and the United States. Wherever they have been in use, they have given satisfaction in every respect.

As already observed, the present descriptions and drawings represent a reheating furnace, of the form and size of those built and used at the Bethlehem Iron-works, by John Fritz, Esq., superintendent of the establishment. They have the advantage of combining the most approved form with carefully designed gas-generators for anthracite coal.

Compared with the present consumption of coals in well-constructed furnaces, the gas-heating system would save about 26 per cent. on fuel, and allow the use of small coal, such as chestnut in the place of lump, or lump and pea coal in equal parts. Another very considerable advantage is the absence of ashes in the hearth, which often prevents a perfect welding, and produces an inferior quality of iron. This circumstance alone is doubtless, a sufficient inducement for the introduction of the gas-heating form of furnace, as the evil influence of cinders is especially felt when fan-blowers are employed, and when large plates of a faultless quality have to be produced. It is further evident, that the gas furnaces will diminish the loss of metal by preventing its oxidation or burning; while the system admits equally, when so desired, an excess of air, and thereby a powerful oxidation, which, especially during a certain period in the puddling furnace, will assist in expelling silicium, phosphorus, and sulphur.

In presenting the great advantages of converting fuel into gas be-

fore its practical application, I wish to state that, although this invention is not new, and has been in actual use for twenty-five years, it is now for the first time brought into a systematical form, based upon scientific principles and facts shown by experience; and Mr. Schinz has certainly the incontestable merit of being the author of this system.

A question of the greatest importance for industry,—the rational use of fuel,—discussed in so many ways in a scientific and practical view, to which a great number of improvements and inventions are attached, has, nevertheless, been solved so far in a very imperfect and irrational way; and good results were more accidental than based upon sound calculations, as already said.

I will not pretend that Mr. Schinz's system is at present of equal advantage for all applications, although it is equally well founded on true principles; but for purposes where intense heat is required, it is certainly the most rational and advantageous of all known. With regard to the presented furnace, I will mention that its first cost is considerable higher than that of ordinary furnaces, but this difference is made up by the saving in fuel within four to six months. It is not to be denied that a close attention and moderate skill is required for its construction, management, and repair; but there is no doubt that, with a strict adherence to the rules laid down, an intelligent manager will find no difficulties, when aided by the good-will of the workmen, to obtain all the desired results.

In the plates *I* to *IV*, we have the different sections of the furnace represented. The six gas-generators are marked *A* 1 to *A* 6; the main canal for the fan-blast with *B*, and the gas-flues, which conduct the gas from the generators into the furnace, with *C* 1 to *C* 6. In plan *IV*, we have in *D* the pipes which lead the cold air from *B*, under the boiler into the hot air pipes *F*, and from there the heated air goes through *H*, into the injector *J*.

In plan *I*, we see in *K* the combustion canal, in which gas and air for combustion are intermingled, from whence they enter with their initial temperature into the furnace, *L*, thence through the flue, *M*, between the boiler and hot-air pipes, to be evacuated in the chimney, *P*.

The *Gas-Generators* are, as will be seen in plate *I* and *III*, 3′ 3″ wide, and in the clear, average 4 feet in height. The doors, *Fig.* 1 *a*, and 1 *b*, plate *V*, close the ash-pits air-tight. In them is a small glass plate, to observe the burning of the coal in the generators.

The step grates are marked in plate *III*, with *A* 1 to *A* 6, and

drawn in details in plate *VI, Fig.* 4; they have a surface of 11.5 square feet each.

The apparatus to charge the coal in the generators is seen in plate *V, Fig.* 2, in detail. On a cast-iron plate, fastened to the wall, plate *VI, Fig.* 22, moves another, plate *V, Fig.* 2, which is provided with a rack, and receives a fire-proof tile within four flanges, which covers the square openings of the first plate when the generator is closed, and can be opened by means of a section of wheel and lever acting on the rack. There is further a box on the upper plate, which receives the coal when the generator is closed, and from which they drop into the latter when it is opened.

The gas which is produced in the generators, is conducted through the gas flues, *C* 1 to *C* 6, plate *I, II, III;* they have 46, respectively 58 square inches opening each, and unite in the space, *E*, below the combustion canal, *K*, from whence they pass the front of the hot-air injector, *J*, and are consumed in the canal, *K*.

Blast Canals. A fan, with a capacity of 1700 cubic feet of blast per minute, delivers the same through the main canal, *B*, plate *I, III, IV*, to the generators to produce the gas, and to the hot-blast injector to consume the same. Two eight-inch pipes, *D*, carry the portion of air for the injector from the main channel in the room below the boilers, where it circulates in a length of about 100 feet, and becomes heated to 612° Fahrenheit in the pipes, *F*, from whence it enters through the pipes, *H*, in the injector, *N*. The latter is represented in plate *VI*, in several sections; has a length of 5′ 9½″ by 1′ 3¾″ height, and 1′ 9¾″, respectively, 6″ width. It is provided with two slide-valves of 50¾″ square opening each, represented in plate *VI, Fig.* 12, by means of which the influx of hot air can be regulated.

The blast for the generators is taken from the main channel through branch-pipes of 6″ diameter, then passes through an aperture in the wall under the respective fire grates. The end pieces are provided with circular slide-valves, having an opening of 31 square inches each; they are represented in plan *III, section G, H, Fig.* 3, and plate *VI, Fig.* 6. By means of these valves and the corresponding gearing and levers, the influx of cold air under the grates is regulated.

The combustible gas which flows through the flues, *C* 1 to *C* 6, unites in the vertically inclined space, *E*, then passes the injector, provided with 52 holes of 1.19″ diameter, through which the hot air escapes and intermingles in so many cones, as holes, with the gas

in the combustion flue, *K*. The latter has a width of 4′ 2″, with a mean height of 1′ 2½″, consequently a cross section of 5.3 square feet, with a length of 4′ 8″. In commencing operations with the furnace, the hot-air valve is closed, the gases pass unburned through the hearth, escaping through all apertures with the blue flame of carbonic oxide gas. Subsequently the air is admitted by degrees, until the flames disappear, and the burnt gases, passing over the hearth, appear clear, bright, and transparent. To avoid oxidation, a little excess of gas is admitted.

The furnace, *L*, has a length of 12′, a width of 5′, and a mean height from hearth to arch of 1′ 11″. The hearth is seen in plate *I, Figs.* 1 and 2, and is built in the usual manner, but may be made as judged best by the constructor. The walls and casing are seen in plate *I, IV.* The arch has a spring of 4 inches.

The boiler is placed above the furnace, as in most cases, and rests, together with the walls, etc., upon six large iron columns with their frames, and upon two supports in the centre. The products of combustion enter from the flue beneath the boiler, and pass all around the hot-air pipes; the boiler is provided with a flue, and offers a total heating surface of 263 square feet, equivalent to at least 22 horse power.

In the several plans, we see the arrangement to support the boiler wall are rails and cast-iron plates. The clear opening of the flue leading to the chimney is here only one square foot, in order to compress the gases in the combustion canal, *K*, but room is left to increase the same, if found necessary, to two or three square feet.

Calculation for the Furnace. The former consumption of anthracite for the furnace is presumed to have been 10.2 tons for 24 hours, or 952 lbs. per hour.

In admitting the most advantageous mode of heating with fan blast in the usual way, and estimating the temperature in the furnace to 2912° Fahrenheit, as the extreme, we have as useful effect:

4161° initial temp. of anthracite.
Minus 2912° temp. of furnace.

1249° divided by 2912°—0.30 = 30 per cent.

The same fuel gives with gas-heating,

$$\frac{4928° - 2912°}{4928} = 0.409, \text{ or } 40 \text{ per cent.}$$

We can consequently diminish the fuel at the ratio of 40.9:30 = 10.2 tons: χ = 7.4 tons, or 27.4 per cent. saving in fuel.

In consuming 699 lbs. of fuel per hour, we have per second 0.194 lbs., which produces 80 cubic feet of gas, with a temperature of 2480° Fahrenheit, requiring 10.59 cubic feet of air, reduced to 32° F. temperature for its production, being 636 cubic feet per minute.

We need further for the *combustion* of 80 cubic feet of gas, 34.3 cubic feet of air at 572° Fahrenheit.

The products of combustion amount to 300.8 cubic feet per second, at the initial temperature of 4928° Fahrenheit.

The formula for produced volume of combustion:

$V = v\,(1 + at)$.

V = expanded volume (300.8).

v = volume at 0° (27.4 cub. feet).

a = expansive coefficient (0.003665).

t = required temperature (2720° Celsius).

The contact surface between air and gas, which is required for a perfect combustion of the latter, is calculated to 122 square feet. The combustion canal being 3′ 8″ long, its cross section = 5.3 square feet, and the number of tuyers in the injector being 52, we can imagine 52 air cones with $0.098 + 0.328 = 0.213$ feet mean diameter, and 3′ 8″ in length. The 52 cones give consequently a surface of $52\,(0.213, 3.14, 3.66) = 127.3$ square feet, a little more than above calculated.

The cross section of the fifty-two tuyers in the injector is $52\,(0.04922.3.14) = 0.39$ square feet; the quantity of air at 572° passing through per minute, $60.34.3 = 2058$ cubic feet, or reduced to 978 cubic feet, at 32° F. and per minute.

The velocity of the air at the tuyers, $V = \frac{2058}{0.39} = 5277$ feet per minute, or 87 feet per second.

The head corresponding to this velocity = 1.5 inch in a water column, or 115.7 feet in an air column.

The velocity V of the same air, when passing at 32° through two tubes of 8 inches diameter, is $\frac{978}{0.74} = 1321$ feet per minute, or 22 feet per second.

The head just mentioned has, however, to be increased somewhat, for two reasons:

First. For the suction caused in the gas-flues by the streaming air; and,

Second. To cause a certain pressure on the air and gas in contact.

In this case we will be safe to add 10 per cent. of head.

The cross section of the gas combustion canal is 5.3 square feet, less the cross section of the tuyers, 0.395 square feet = 4.905 square feet. The quantity of gas entering this canal is 80 cubic feet per second, or 4800 cubic feet per minute. The velocity will be then at its entrance, $V = \frac{4800}{4.905} = 978$ feet per minute, and 16.3 feet per second.

As the smallest cross section of the gas-flues is = 3.85 square feet, we have the velocity in them, $V = \frac{4800}{3.85} = 1246$ feet per minute, and 20.8 feet per second, with a corresponding head of = 0.087 inches in a water column, or 6.74 feet in an air column. The pressure in the air pipes, branching out from the main canal and leading to the hot air apparatus, being necessarily the same as that of the tuyers in the injector, = 1.5 inches in a water column, we have to regulate the circular valves, so as to admit per second 10.59 cubic feet of air under the same pressure $= \frac{10.59}{87.6} =$ 0.0203 square feet for each generator = 3 square inches.

The amount of consumed coal per hour is 952 lbs. for six generators, and 158 lbs. for one, and per hour.

The open spaces of the coal are estimated to be about 2.14 square feet for each grate, and the velocity of produced gas in the generator $= \frac{80}{2.146} = 6\,23$ feet per second.

There were 18048 cubic feet products of combustion at a temperature of 4928° Fahrenheit, per minute. As they pass under the boiler with a temperature of 2912° Fahrenheit, their volume is reduced to 7320 cubic feet (27.46. [4.46.60]); and when they leave the boiler with an estimated temperature of 1301° Fahrenheit, it is further reduced to 5832 cubic feet (27.46. [3.54.60]), by the diminished expansion.

We would have then a velocity of $\frac{5832}{60} = 97$ feet per second.

The cross section of the entrance of the gas in the chimney is 1 square foot, and the corresponding head = 1.86 inches in a water column, or 144 feet in an air column.

Comparing this head with that necessary for the passage of the gas into the gas-flues, we find that we have an excess of = 144 — 6.74 = 137 feet of an air column. This pressure is too much, for the hot gas would escape through the working doors, to the injury of the workmen. But in making the cross section 2 square feet, the velocity would be $\frac{5832}{60.2} = 48.6$ feet, and to corresponding head = 35.2 feet

in an air column, leaving consequently a surplus of 35.2 — 6.74 = 28.46 feet in the combustion canal, *K*.

Management of the Furnace.—We have here omitted entirely all calculations regarding resistances, etc., as more or less irregularities in the practical working cannot be avoided, and as, consequently, such calculations would be quite illusory.

It will be, however, of much benefit, to use in connection with the furnace a multiplicator manometer, of which we give a sketch with the furnace plans.

The manometer has been known for a long time as a useful instrument to measure the pressure of blast produced by blast machines. The latter is generally of a higher pressure, so that minute divisions on the manometer scale are of not much importance, and the usual instrument is rather inconvenient, as it needs very close observations to see the oscillations corresponding to small differences in the pressure. For very low pressure, however, the usual manometer is not admissible, as it would be difficult, if not impossible, to determine such small differences as parts of an inch in a water column. It was Peclet who first proposed a manometer, which answered the purpose of measuring very small pressures; Mr. Schinz improved the same materially, and presents it in the following construction:

Fig. I, to III, represents a sheet-iron box, *g*, of 20″ length, 6″ breadth, and 4″ height, with a separate capsule of 4½″ diameter within, which reaches nearly to the bottom of the box, and is open on both ends.

The cross section of the box, inclusive the capsule, is 20.6 = 120 square inches; the cross section of the capsule is ¼. (4½².314) = 15,896 square inches.

The highest pressure of the wind is calculated in this case to 2″ in a water column. If we have that pressure, the height of the water in the box will be 1″, and in the capsule 3″. As soon as this pressure ceases, the water in the box will rise in proportion of 120: (2 + 15.896) = 0.2649″ (as the capsule contains 2.15896 cubic inches), above the original water-level in the box, and at its sinking, the water in the latter rises 0.2649 inches. If we lower the level by a pressure of 2″, the water in the capsule consequently rises only 2 — 0.2649 = 1.7351″.

This movement is now to be transferred to a mechanism which shows this difference multiplied on a circle or a part of it. This mechanism consists simply in a swimmer, *a*, from which a silk thread, *b*, goes over a roller, *c*, and is counterbalanced by the weight, *d*.

The hand, *e*, has a length of 18″, which multiplies, therefore, the movement of the roller, *c*, and shows it on the arc, *l*.

The cord of this arc has a length of 24″, and the angle at *c*, = 84°. The arc itself has 26.376″ in length, which the hand, *e*, has to pass to make a pressure of 2″.

It is of importance now to give the exact diameter to the roller, *c*, so that the hand describes exactly the rise of the water of 1.7351″. The angle at *c*, being 84°, the roller, *c*, must have a diameter corresponding to 1.7351″ for an arc of 84°.

This diameter is $d, = \frac{360.1.7351}{84.3.14} = 2.3682.$

The length of the arc being 26.376″, every inch is equivalent to a pressure of $\frac{1.7351}{26.376} = 0.06578.$ *Fig.* 1, of the drawing, represents a longitudinal section; *Fig.* 2, a front view, and *Fig.* 3, a cross section. *A*, is a wooden frame, or rather a box, with a door, *B*, and a window-glass, *C*, at its face. *D*, is the sheet-iron box within; *a*, is the swimmer, *b*, the silk thread, and *d*, the counter balance; *c*, is the roller in *Fig.* 4, in natural size, only designed for a pressure of one inch. The roller, *c*, is supported by the iron plates, *f*, fixed by means of small screws to the wooden frame; *e*, is the hand, and *g*, denotes the sides of the water-box; *h*, is a small tube, closed by a cork, *m*, to regulate the water in the box, and *k*, another tube, to put the manometer in communication with the blast tube; *i*, is a glass pipe, to show the level of the water, and to mark any disorder of the instrument.

Mr. Chase made a communication on the traces of common radicals in the numeration of various languages, and on the original ideas involved in the names of the numbers.

ON THE RADICAL SIGNIFICANCE OF NUMERALS.

The facility with which the vowel u and the nasal consonants combine with letters of every contact,* may, perhaps, naturally account for their frequent occurrence in the formation of the substantive verb;† but it is difficult to explain the various derivative ana-

* See *ante*, Vol. IX, p. 273.

† Eg. au, un, *to be*, ua, *one;* Cp. un, *to be, one;* L. sum, unus; Gr. εἰμί, ἷνα; Ger. ein; Dk. uŋ, waŋka, *to be*, waŋća, *one;* Y. wa, ni, *to be;* C. we, *to be;* E. was, were.

logues which appear to be based upon the idea of simple existence, in any other way than by the hypothesis of a unitary origin.

If any conclusive traces of such an origin are still discoverable, we may reasonably look for them in the numeral adjectives, and in other words which denote the simplest and most universal ideas, such as being, man, one, I, near. The words that we have instanced may be so easily associated, that it would not surprise us if their originals were all formed by modifications of a single primitive root, and I think the Aboriginal languages of America furnish us with a pretty satisfactory clue to that root, and to some of its earlier transformations.

We find, for example, Dk.* uŋ, waŋka, *to be*, waŋ, waŋka, waŋća, *a, one;* Om. ango, *we are;* Ch. Yih ko, *one*, ngo, no, wo, *I;* L. ego, nos; Ak. ako, *one;* Y. ako, *a male, first* (in compound words); Sh. nok, *one;* H. anokhi, Cp. anok, Eg. anuk, *I;* Sha. nicoti, Pa. necat, Po. ngot, Le. nguti or cvati, *one;* Sh. niko, *near* (in inikoyots, *to arrive at a place*, enikota, *to draw tight*); Mn. naka, Cr. hineka,

* The Indian words are taken from Riggs' Dakota Dictionary, Haldeman's Analytic Orthography (Trans. A. P. S. Vol. XI), Hayden's Ethnology and Philology of the Indian Tribes of the Missouri Valley (Ibid. Vol. XII), Gibbs' Dictionary of the Chinook Jargon, and Rasle's Abnaki Dictionary. I am also indebted to Prof. Haldeman's valuable essay for many Oriental numerals.

ABBREVIATIONS.

Ab. Arabic.	Cr. Crow.	Nd. Nadaco.
Abn. Abnaki.	Dk. Dakota.	Om. Omaha.
Ak. Arikara.	E. English.	Os. Osage.
Ap. Apache.	F. French.	Pa. Passamaquoddy.
Ar. Arapoho.	G. German.	Pn. Penobscot.
Arm. Armenian.	Gb. Grebo.	Po. Potewatemi.
At. Atsina.	Go. Gothic.	Pr. Persian.
Bl. Blackfoot.	Gr. Greek.	Pw. Pawnee.
C. Chinese.	H. Hebrew.	S. Sanskrit.
Cd. Coordish.	Hb. Irish.	Sh. Shyenne.
C. F. Cape Flattery.	Hm. Hamitic, or Egyptian.	Sha. Shawanee.
Ch. Chippewaẏ.	Ip. Ipai.	Sy. Syriac.
Chc. Choctaw.	Ir. Iroquois.	Tm. Tamil.
Chk. Cherokee.	Kn. Kansas.	W. Welsh.
Ck. Creek.	L. Latin.	Wa. Waco.
Cl. Chaldee.	Le. Lenape.	Wl. Wallachian.
Cn. Chinook.	Ma. Malay.	Wy. Wyandot.
Co. Comanche.	Mn. Mandan.	Y. Yoruba.
Cp. Coptic.		Yu. Yuma.

now (nearness in time); Bl. anuks, nakotsio, *small;* S. nicaſa, Y. nikusa, G. nach, W. nig, E. nigh; Ar. nakait, At. nakasć, *to sleep* (i. e. *to draw the eyes tight*), Ma. nok, *sleeping with the eyes,* Ak. hinuk, *night,* S. nactam, *at night,* Gr. *νύξ*, L. nectere, nox, nux. The association of the ideas of unity and nearness is confirmed by Abn. pezeku, *one,* pessut, *it is near.*

Traces of a common radical are found in many of the words which denote *one* and *ten.* E. g. Sh. nok, *one;* Ak. nukini, *ten;* Pw. peta, *man,* Cree. peet, *one,* Ak. pit, *one* (in pitiku = pit ako = 1, 1 = 2), Tm. paty, *ten;* Bl. matapi, *man,* Cr. hamat, Ck. hemkin, Mn. macana, Am. meg, mi, Gr. *μια*, Kn. miectse, *one,* Eg. met, mnt, Cp. met, Cree mitatat, wetatat, Sh. matokts, Ar. metaitok, At. matatasits, Ch. mitaswi, Sha. matatvi, Po. matatso, Pn. mdala, *ten.*

From roots indicative of division may be derived words signifying *one* (a piece), *two* (divided), *five* (one hand), *ten* (one tale, or one completed count). E. g. Ap. tahle, *one,* Chk. tali, *two,* Chc. ta*θ*lapi, Esk. tetlamet, *five,* Le., Pa. telan, *ten,* E. deal, dale, tale, tally, toll; Ck. hokolin, Chc. tuclu, *two,* Chc. pucoli,* *ten;* Ap. daki, Ir. tekin, *two,* Pa. dec, *ten?* (in escvonadec, *nine* = 10 — 1) Gr. *δεκα*; Nd. vistsi, *one,* Wa. vitf, *two,* L. bis, Nd. bit'h, *two,* binaja, *ten,* Yu. kavic, *two,* Dk. koviŋ, *two* (in ſakoviŋ, *seven* = *second two*), Ir. uisc'h, Wy. uvif *five,* S. vi, a particle denoting *division* or *separation,* S. dvi, C. tuy, *a pair.*

A portion of the roots which appear to be properly embraced in this class, deserve especial notice on account of the important part that they play in the formation of the numerals from six to ten. Among their analogues are L. seco, secundus, sequor; S. satſ, C. suy, F. suivre; Cr. akpi, *added to;* Dk. ake, *again,* saŋpa, *more;* Ar. thakuina, *to follow after one.* E.g. Chk. sacvo, Ir. asca, Wy. scat, Pr. pesac, C. F. tſacvak, *one;* Sha. nisvi, *two;* Le. cvataſ, 6 = *second one,* niſaſ, 7 = *second two,* χaſ, 8 = *second three;* Ch. i‚godvasvi, *second one;* ni‚ɟvasvi, *second two,* niſvasvi, *second three;* Pn. necud-as, *second one,* tamba‚v‚-as, *second two,* nsa‚-sac, *second three;* Sha. nicotva*θ*vi, *second one,* nisva*θ*vi, *second two,* n*θ*vasic*θ*vi, *second three;* Dk. sakim, *both,* ſacpi, *second one,* ſacoviŋ, *second two,* ſacdogaŋ, *second three;* C. F. aclesab, 8 = *two from the second,* sacvasab,

* This root c–l is probably a corruption of the preceding t–l. For we find Chk. tali, *two,* calcvoci, 2 + 5, *seven;* Ck. hokolin, *two,* culapacin, *seven.*

9 = *one from the second;** Ip. ſakoq, Yu. sakoq, Chr. scahi, C. sap, Ma. sablas, *ten.*

In some of the Algonquin dialects, the word palin is used for *five* or *ten.* E. g. Ck. palin, *ten;* Le. palinaχ, or palinuˌc, Pn. palinascu, = *one palin, five.* The resemblance to Gr. *πάλιν* is significant. We find in Chinese pa, *to turn the back upon, to put asunder,* pa′, *numeral of things grasped with the hand* (compare S. pantſan, Co. manucht, *five,* L. manus, Hm. mn, *fore-arm, shin*), lin, *five families, neighbors, the appearance of numbers.*

Some successive probable derivations can be traced to an extent that is wonderful, considering that the languages have no literature or other means of checking dialectic variations. Thus a satisfactory connection, in my opinion, can be traced between Wa. tau, *three,* and Dk. loga (in shageloga, *eight* = *second three*), through the intermediate forms Dk. dogaŋ, Le. naχa, Nd. dahau, Wa. tau. Le. aſ, *second,* and Wa. tau, *three,* give S. aſtau = Gr. *ὀκτώ, eight.* Po. ſaca, Kn. ſoŋca, Dk naptſioŋka, naptſiŋwaŋka, *nine* (nape, *hand,* napin, *both,* napin-tſiŋ-waŋka = *both wanting one*), are all probably affiliated.

Some instances of special resemblance, which, if unsupported, might be regarded as accidental, are entitled to consideration in connection with the broader analogies that have been pointed out. Such are Co. semmus, *one;* Ma. sembilam (*one from ten*), *nine;* Cn. elip, *first, before,* H. aleph; Ip. sin, C. sing, L. singulus, *one;* C. si, Pa. sis, Cd. sise, Pr. si, *four;* Ak. ćatiſ, S. ćatur, *four;* Wy. tsutore, Ir. tsata, S. saptan (all of which may be formed by Vesperian roots signifying *second two*), *seven;* Ak. nukinivan (= *one from ten*), S.

* Duponceau, in his Volney prize essay (Mémoire sur le Système Grammatical, &c., p. 59), makes the following reference to the Algonquin numerals. "Mais de cinq à dix ces langues suivent une autre méthode, et c'est la meme que celle qui a été suivie par l'inventeur de chiffres romains. Pour six, on dit cinq un, pour sept cinq deux, pour huit cinq trois et pour neuf un dix, c'est-à-dire dix moins un, ce qui répresente exactement les caractères numeriques VI, VII, VIII, IX. Cet ordre d' idées n' existe point dans la langue de l'ancienne Rome, et cependant se trouve dans sa numeration écrite et abrégeé. D'ailleurs on ne l'aperçoit point dans la formation des noms de nombre des autres langues connues."

Hager (Explanation of the Elementary Characters of the Chinese, &c.) has pointed out the resemblance of the Chinese and Roman numerical characters, and I subjoin some of my reasons for believing that the resemblance is traceable in many of the Aryan, Shemitic, Hamitic, and Turanian languages, as well as in their "numeration écrite et abrégeé."

navan, L. novem, *nine;* At. enanapetasits, Gr. ἐννέα; Gb. pu, Chc. pucoli, Bl. kipua, *ten.* I have elsewhere* suggested the affinity of S. ćatur and C. ćat ur, *doubled two;* analogues to ćat are found in Ak. ćitu, *the whole,* Ar. ćia, *again,* Dk. ići, *together,* oćitkoŋza, *equal;* ur is equivalent to Le. aſ, *second;* ćatiſ & tsutore may, therefore, be reasonably regarded as the precise equivalents of Oriental ćat ur.

There are some anomalies, for which I have been unable to hit upon any explanation that entirely satisfies me. E. g. Sh. nok, *one,* Bl. nok, *three;* Sha. nisvi, *two,* Ch. nisvi, *three,* Bl. nisvi, *four;* Dk. zaptaŋ, Os. sata, *five,* S. saptan, Ir. tsata, C. tsat, tſat, *seven.* The analogies may probably be best accounted for by roots signifying *division* or *sequence.*

If Ip. and Yu. *sin,* Co. *sem,* C. *sam,* are, as seems very probable, allied to S. sam, Gr. σύν, L. sumo, con, cum, Hm. sm, *to gather,* we can trace some very interesting resemblances to the monumental Egyptian or Hamitic numerals. E. g.

One. Hm. ua, uot; Dk. waŋ; Ak. wan; Tm. wana꞉; L. unus; Po. ngot.

Two. Hm. snau, sente; H. ſne, ſnim; Gb. sa꞉. The root ſn in some of the Shemitic dialects is modified into θn or trn, as in Ab. iθnain, Cl. tren, Sy. trin (compare Tm. rendu? L. semi?).

Three. Hm. χament, χamet;† Ip., Yu. χamoq; C. sam; Gb. ta꞉ (Cn. qˡqlon? Ap. tʰhe?); Le. naχa; Mn. nameni; Dk. yamni. The above-noted Shemitic equivalence of ſ and tr, may account for the Aryan form tri.

Four. Hm. ſtu, ſtou; Che. uſto; Os. toba. Bunsen suggests that ſtu may be derived from 1 + 3. From Vesperian analogy, as well as from the Hm. forms for five and seven, I suspect that f is another form of the root of division, vi (compare L. findo).

Five. Hm. tu, tiu (*a division?*). Compare C. woo, Wy. uviſ, *five;* Chc. tuclu, *two;* Sy. trin, *two;* Wl. trintſ, *five.*

Six. Hm. sou, so (*second* or *following?*). Compare C., Cl. suy; Dk. ſakpi, S. ſaſ, H. ſeſ, *six;* L. sex, secundus.

Seven. Hm. saχf, saχfe, χasfi; Dk. ſakowiŋ; H. ſeba꞉; Go. sibun Hb. ſoct.

Eight. Hm. χmen, χmeni (*second three*); H. ſmnah. See Three.

* Chinese and Indu-European Roots and Analogues, p. 2, and *ante* v. VIII, p. 11.

† χ inclining to ſ.

NINE. Hm. psit; Le. peɬcu¸c (= pesac, *one* [*sum ?*], ćiŋ, wanting, waŋka, *one*); Bl. piksua.

TEN. Hm., Cp. mnt, met, meti; Sha. metatvi; Po. matatso; Cree mitatat, mitatano; Shy, matokto; At. matatasits. Compare Cp. meti, *half;* L. medius, dimidium; S. madhya¸; Y. medji, *two.* Roots denoting measurement (metior, mete, &c.), may very naturally have been derived from the same root as met, *ten.*

From comparisons like the foregoing, it appears that the primitive numerals, so far as I have been able to trace their probable origin, were intended to convey the following ideas:

ONE. Existence, a piece, a group.
TWO. Division, repetition.
THREE. Collection.
FOUR Twice two.
FIVE. Hand, division, collection.
SIX. Second one, five-one, twice three.
SEVEN. Second two, five-two.
EIGHT. Second three, five-three, twice four, two from ten.
NINE. One from ten, three threes.
TEN. One (group), two (fives).

Pending nominations Nos. 534, 535, 536, and 537, were read.

A discussion took place respecting the remaining volumes of Duponceau's Memoir on the Chinese Language.

And the Society was then adjourned.

Stated Meeting, March 3, 1865.

Present, ten members.

Dr. WOOD, President, in the Chair.

A letter inclosing a photograph was received from Mr. C. A. Schott, dated Washington, March 1, 1865.

Donations for the Library were received from the Royal Astronomical Society, Prof. James Hall, the Franklin Institute, the Academy of Natural Sciences in Philadelphia, the National Academy, and Mr. C. H. Hart.

The Secretary laid on the tables copies of the Proceedings No. 72, just published, with revised lists of the members, &c.

Mr. Marsh communicated the results of calculations in reference to the heights of the auroras of January 16, and February 20 and 21, which led to a prolonged discussion of magnetic phenomena by the members present.

About 7 o'clock on the evening of January 16, at Germantown (lat. 40° 1′ long. 75° 11′), my attention was called to a bright mass of white auroral light, stretching E. and W. from horizon to horizon, in the form of a pretty regular and well-defined arch, 2½° to 3° in width, having its highest point marked very nearly by Zeta Ursæ Majoris. Below it only a dark segment was observed. Of its position and appearance from time to time, I made the following notes:

H.	M.		
7	0	P. M.	Upper edge reached Zeta Urs. Maj., or very nearly so; outline regular.
7	10	"	Upper edge reached Zeta Urs. Maj., or very nearly so; outline irregular.
7	15	"	Upper edge reached 1° below Zeta; outline not well defined.
7	30	"	Upper edge reached 1° @ 1½° below Zeta; bright.
7	38	"	Upper edge reached 2° below Zeta; bright.
7	58	"	Upper edge reached 1½° below Zeta; bright.
8	8	"	Centre of arch 1° above centre of line joining Zeta and Eta; bright.
8	15	"	Centre of arch 1° above centre of line joining Zeta and Eta; upper edge 2° below Zeta; bright.
8	23	"	About the same; very bright; the whole width of light between Zeta and Eta.
8	35	"	Aurora more extended; very bright in N. W., but clouds interfered with its exact location.
9	30	"	Quite cloudy; light more diffuse; higher.
9	45	"	Arch bright; rather higher; apparently a mere opening in the clouds.
10	15	"	Entirely obscured by clouds.

The width of the arch, at least in the part to which the above notes particularly refer, remained nearly constant. No streamers seen, and only white light.

The "Telegraph," published at Brunswick, Maine (lat. 43° 53′

long. 69° 55′), contained the following notice by the editor (Mr. A. G. Tenney):

"We observed a magnificent aurora on Monday night, just about 8 o'clock. At that hour it formed two bows, the larger and exterior one spanning the sky from N. E. to N. W., at an angle of about 45° at its greatest elevation above the horizon, while the interior bow extended only a few degrees, and rose not more than 4° or 5° above the horizon. Both were as perfectly marked, well defined, and distinct as any rainbow that we ever saw; although, in the case of the aurora, the bows were broad bands of light, the larger one covering several degrees of the heavens."

Mr. T. informs me that the estimated altitude was obtained by fixing his eye upon what he supposed to be the zenith, and then running it down to the upper edge of the bow, and estimating the proportional parts. On going again to the same spot, and recalling as nearly as possible the position of the arch, he was confirmed in his original estimate. But subsequently being furnished with a star chart, upon which he could trace its position, he satisfied himself that his figures were too high, and the path which he finally marked upon the chart as the result of repeated trials, indicates an elevation of only 32°. In view of the well-known tendency, in all unpractised observers, to underestimate zenith distances, this change is about what might have been anticipated, and the corrected result seems to be entitled to confidence as an approximation.

Eight o'clock at Brunswick corresponds to 7h. 39m. at Germantown, at which time my notes show that the upper margin was about $1\frac{1}{4}°$ below Zeta, or about $7\frac{1}{2}°$ above the horizon.

Taking as a base line the difference of latitude (3° 52′), and combining these results, we get for the actual height of the arch from the surface of the earth, 67.3 miles.

On the 20th of February there was another arch, which was thus noticed by Dr. Henry C. Perkins, in the "Newburyport Herald" of the following day:

"As the Pleasant Street clock struck eight last evening, a brilliant arch, about 6° or 7° in width, spanned the heavens from east to west; involving in its luminosity the four stars in the head and neck of Leo; passing about 2° to the north of Castor; having Capella on its southern edge, inclosing Perseus and Andromeda in its folds, and thence coming more directly to the west. It was quite uniform in its width and brilliancy, but lasted only a few minutes."

This description shows that this arch passed through the zenith at

Newburyport, its southern edge having an elevation of about 89° above the southern horizon.

Fortunately, Mr. Tenney was, at the moment of its formation, engaged in correcting the altitude of that of January 16. He says:

"Whilst we were looking this evening, at 8 o'clock, there was a magnificent auroral display, mostly, however, made up of shooting beams. But all at once an arch was formed—say about 3° wide (and as it passed through the belt of Orion I have a good measure for that), the upper edge cutting just below Venus, and so on through Orion, that being its greatest elevation, and losing itself near the horizon a little south of east. The arch lasted but a few moments, but for an instant or two it shone magnificently."

By tracing on a globe an arch 3° wide, passing through the belt of Orion, and similar in form to that indicated by Dr. Perkins's observations, we get a probable elevation of 41° for the southern margin, which, combined with the Newburyport elevation, gives 67 miles for the height of the arch.

This arch was also seen at Dr. C. Smallwood's observatory, at Montreal. He says:

"At 7h. 50m. P. M." (exactly 8 o'clock, Newburyport time), "an auroral arch was seen from this place, stretching from horizon to horizon E. and W., passing through the constellation Orion. It was from 2° to 3° in breadth, and lasted about 18 minutes."

Assuming this arch to have had the exact form and position of a parallel of latitude at the height of 67 miles over Newburyport, it must, as seen from Montreal, have had a much less elevation than any of the bright stars in Orion, and could not, therefore, be said to "pass through" that constellation.

This discrepancy may, probably, have resulted from irregularity of form in this arch, combined with peculiarity of position. A glance at a globe, in connection with Dr. Perkins's report, shows that in this instance, as in several others recently, the pole of the arch was considerably to the east of north. Consequently, Brunswick, which is N. E. from Newburyport, is much more favorably situated for comparison with that place than Montreal, which is N. W. The part of the arch nearest Brunswick, is that which is nearly vertical over Newburyport, and observers, therefore, look at the very same object; whereas that nearest Montreal lies much further N. W., and may be quite different in form.

Results based upon the former appear, therefore, entitled to considerable weight, notwithstanding their disagreement with the latter.

It is evident, however, that the same peculiarity of position would require that the length of the base line, and, consequently, the height, should be somewhat increased for Newburyport and Brunswick, and diminished for Newburyport and Montreal.

Another arch, seen on the evening of February 21, is thus noticed by Robert Treat Paine, of Boston, in the "Daily Evening Traveller," of the 22d:

"At half-past 8 o'clock, bright branches of white auroral light appeared in the N. W., and also in the N. E., which at 8h. 45m., ran together, and formed a luminous arch from N. W. to N. E., the centre of which passed a few degrees above the pole star. The arch, however, was of short duration, as it continued only three or four minutes, and at ten minutes before 9 o'clock, the aurora had entirely disappeared."

H. D. Vail, at Philadelphia, carefully noted at 8h. 15m. (8h. 31m. Boston time), the position of the upper margin, its highest point being halfway between Gamma Ursæ Minoris and the horizon, or at an elevation of about 13½°. He did not continue his observations, but at 8½ o'clock (8¾, Boston time), William Dennis, at Germantown, estimated its altitude at 15°.

As Mr. Vail reports the arch seen by him to have been regular and complete, it is evident that the break existing north of Boston at 8½ o'clock, was too far east to be visible at Philadelphia, and what Mr. V. saw must have been far to the N. W. of Boston.

Mr. Paine informs me that his attention having been mainly directed to the N. E., he is unable to speak confidently as to the exact location of the auroral branch in the N. W.; he has, however, marked on a star chart his impressions as to the positions at 8½ and 8¾ o'clock respectively, showing a probable altitude for the highest point, of 42° for the former, and 50° for the latter.

The above altitudes, 13½° and 42° combined, give the height at 8h. 30m. Boston time, 64.8 miles; at 15° and 50° combined, at 8h. 45m. Boston time, 66.2 miles.

While the extreme closeness of agreements in these results for January 16, and February 20 and 21, is, of course, accidental, the average height (66¾ miles), seems fairly entitled to weight as a rough approximation, and in the present state of our knowledge, even such are valuable.

The results in this case agree with most others on record in indicating that it is only in auroral displays of the very first class that, in our latitude, at least, the "arch," or "curtain," is at a less height

than 50 miles. In the grand display of August 28, 1859, the height was 43 to 46 miles;* and in that of September 2, 1859, it was 50 miles. On ordinary occasions, the arch does not seem capable of penetrating the atmosphere to so great a depth.

Dr. C. Smallwood, of the Montreal Observatory, sends the following notes of observations made during a drive which was commenced before 7 o'clock on the evening of January 16; but as the exact time was not noted, they are not available for comparison in the above.

"Time, from before till after 7 P. M. Dark auroral bank in the north, surmounted by a bright auroral arch of a greenish or yellow hue, about 25° to 30° in altitude. This lasted for some hours. An auroral bow or arch stretching from horizon to horizon, due E. and W., passing the zenith, of 2° to 3° in breadth, of the same color as the other auroral appearance. Its southern border was bounded by Beta Orionis, its northern border by Procyon. It lasted a considerable time, say twenty minutes, and exhibited a very distinct and well-defined arch. It gradually vanished, but the auroral bank and appearance remained part of the night."

Mr. Tenny, also, noted another bright arch at 10 P. M. February 20, at an elevation of 12° and 15° from N. horizon; also, a fine one on the 22d, and an imperfect one on the 25th.

Of another on the 21st February, Dr. Perkins writes as follows:

"On the same evening (Tuesday), a most beautiful arch formed in the north, and became elevated, say about 8° or 10°. It was of a bright crimson hue at the base, green above this, and yellowish white above the green, looking somewhat like a low rainbow, only differently colored, its width about 5°. Soon after it was completely formed, streamers began to shoot upwards from its eastern extremity, which gradually, but rapidly, extended themselves towards the west, using up the arch entirely as it progressed, just as a slip of paper would be used up in setting it on fire at one end and burning it up."

Of the frequent auroral displays of the latter part of February, this is the only one in which streamers played a conspicuous part, the whole series being remarkably characterized by the *exclusive* prevalence of auroral "arches."

Pending nominations, Nos. 534, 535, 536, and 537, were read.

And the Society was adjourned.

* Journal of Franklin Institute, 3d series, vol. 38, p. 353. Am. Journ. Science, 2d series, vol. 32, pp. 320, 322.

Stated Meeting, March 17, 1865.

Present, twelve members.

Dr. Wood, President, in the Chair.

Letters were read from A. Erdman, Director-in-chief of the Geological Survey of Sweden, dated Stockholm, November, 1, 1864, and from Dr. W. Merkel, Secretary of the Natural History Society at Nürnberg, dated June 15, 1864, both announcing donations for the Library of the Society.

Donations for the Library were received from the Royal Geological Society, the Society of Arts, the Royal Institution of Great Britain, the Royal Society, the Director of the Magnetical Observatory at Toronto, Canada West; the Engineers of Mines at Paris, the Natural History Society at Nürnberg, the Director of the Geological Survey of Sweden, the Imperial Academy of Sciences at St. Petersburg, Professors Silliman and Dana, Messrs. Blanchard & Lea, and Mr. C. H. Hart.

The death of Dr. T. B. Wilson, a member of the Society, on the 15th instant, was announced by Dr. Bridges, and Mr. Lea was appointed to prepare an obituary notice.

Mr. Briggs referred to machinery used for extracting gold from the ores of Colorado, and described the construction and operation of some modifications recently introduced. The ore is quickly reduced to an impalpable powder, and very minute atoms of gold are readily separated from the matrix, largely increasing the product. He also referred to the use of the vapor of mercury, instead of the metal itself, in the ordinary process of amalgamation for the separation of gold.

Pending nominations, Nos. 534 to 537 inclusive, and new nominations, Nos. 538, and 539, were read.

And the Society was adjourned.

Stated Meeting, April 7, 1865.

Present, fourteen members.

Dr. Wood, President, in the Chair.

A letter accepting membership was received from Dr. G. Smith, dated Oxford, February 16, 1865.

A photograph likeness of Col. J. D. Graham was received, dated March 28, 1865.

A letter inclosing a photograph of casts of Indian hieroglyphics cut in the rocks at Safe Harbor, on the Susquehanna, was received from Prof. T. C. Porter, of Lancaster, dated April 1, 1865.

"I inclose much reduced photographic copies of figures carved by the Indians on two gneissic rocks (A and B), in the Susquehanna river, below the dam at Safe Harbor, Lancaster County, Pa., drawn from casts in plaster, taken under the auspices of the Linnæan Society of Lancaster County, in the autumn of 1863 and the summer of 1864. The casts are boxed up and ready for sending to the Smithsonian Institution. The largest figure is over three feet in length. When the season arrives, we will secure for you a full set of casts in plaster, from which accurate drawings can be made.

In the month of September, 1863, the existence of figures chiselled out by the red men of our stone period on certain rocks in the Susquehanna River became known to the Linnæan Society of Lancaster County, and a committee was appointed, with the president, Prof. T. C. Porter, as chairman, to visit those rocks and obtain casts of the figures in plaster. The work was begun and carried on during the month of October, but not completed till the summer of 1864, the rocks being accessible only at a low stage of the water. Drawings on a greatly reduced scale were made from the casts by Mr. Jacob Stauffer, and photographic copies, still more reduced, by Mr. W. Gill, members of the Society. Those under the letter A belong to the larger rock, and those under B to the smaller one. The intention is to furnish the American Philosophical Society with a full set of casts, in order that a permanent record may be secured in their Transactions. Search for the implements used in cutting out

the figures has, as yet, been unsuccessful. The following facts were collected and reported by the committee.

Position of the Rocks.—The Susquehanna river below the dam at Safe Harbor, Lancaster County, is filled with a multitude of rocks and rocky islets, various in size and extent, between which, the fall being considerable, the water rushes, forming a series of rapids and eddies, navigable only by canals. The width of the stream at this point is scarcely less than a mile, and the jurisdiction of Lancaster County extends to low-water mark on the York County shore.

Among these rocks are the two in question.

The larger one, A, lies a full half mile below the dam, in a line nearly due south from the mouth of the Conestoga.

The smaller one, B, is situated about 250 yards further up, in the same line, at a distance of some 400 or 500 yards from the eastern shore.

The currents around both rocks are strong and swift.

Their Character.—Each rock is composed of several masses overlying each other at an angle of 45° down stream, the lines of division running east and west, the southern crest being the highest. They consist of gneiss, which is rather friable within but hard on the outside. The surface is roughened by grains of quartz, and here and there are seen distinct veins of the same material. The portions facing up stream have been rounded and worn smooth by the action of ice and drift-wood during the high freshets of early spring, as may be inferred from the logs piled upon and around them, and from the striæ or grooves on the larger rock, produced probably by angular pieces of stone imbedded in cakes of ice. Each rock has also, extending a little distance below it, a tongue of land on which grow dwarf oaks, dogwoods, and a few herbaceous plants.

Their Dimensions.—Rock A measures through the centre, from north to south, 82 feet, and from east to west 40 feet. It slopes gradually upward from north to south; the lowest part being 9 feet, and the highest 16 feet above low-water mark. This rock is said to be the highest in the river near Safe Harbor, and from its flat summit the prospect is extensive and beautiful.

Rock B measures, from east to west, on the north side, 20 feet; on the south side, 29 feet 8 inches; from north to south, on the east side, 12 feet 9 inches; on the west side, 8 feet 6 inches. The height on the west side above low-water mark is 6 feet; of the east side, 12 feet 9 inches.

From the east side a huge mass has been broken off, perhaps

during one of the ice-gorges which sometimes occur in the river at this spot. It has fallen into the bed of the stream with the fractured end uppermost. Its length is 12 feet 9 inches, and its computed weight 27 tons. The oldest fishermen about Safe Harbor know nothing, either from their own observation or from tradition, as to when the disruption took place; and yet it must have happened since the figures were cut upon the rock, for those found on the outer perpendicular face of the fragment evidently belong to the same series as those on the upper level surface with which it was once continuous.

*The Figures.**—The two rocks contain in all upwards of 80 distinct figures, and a number more almost obliterated. They are much scattered, and seem to have been formed without regard to order, so that it is not possible for an unskilled observer to say that they bear any necessary relation to each other. They are probably symbolical, but it is left to those who are versed in American antiquities to decipher their meaning.

Some points, however, are clear. They were made by the Aborigines, and made, at a large cost of time and labor, with rude stone implements, because no sharp lines or cuts betray the use of iron or steel. This, in connection with their number and variety, proves that they were not the offspring of idle fancy, or the work of idle hours, but the product of design toward some end of high importance in the eyes of the sculptors.

Letters requesting subscriptions to historical publications were received from J. G. Shea, No. 83 Centre Street, New York, and Rice, Rutter & Co., Philadelphia, and referred to the Library Committee, to take order.

A letter requesting a copy of the seal of the Society for use in his forthcoming book on American Seals, was received from A. B. Weymouth, No. 9 Green Street, Boston, and on motion granted.

A communication was received from Mr. P. W. Sheafer, in the form of a MS. section, showing the levels relative to tidewater of the various coal and oil regions of the United States, in a letter dated March 20, 1865. The MS. has been used by Mr. Eli Bowen, in publishing his late work on coal and coal oils.

* See Plate I.

Mr. Lesley took occasion, in presenting this communication of Mr. Sheafer, to describe the method of the existence of the petroleum in the eastern coal-field of Kentucky, which he had lately visited.

The whole surface of that part of the State of Kentucky, watered by Paint Lick Creek and its tributaries, is a mass of hogback ridges, sharp conical hilltops, and profound rock gorges with steep or vertical walls, bordered by a broken highland of coal measures. The highest hilltops of which are about 700 feet above the beds of the deepest gorges, or cañons.

The wildest and most beautiful scenery meets the eye at every turn; long walls of rock, with their edges against the sky; extraordinary piles of pulpit-rocks, standing isolated at the junction of two streams; overhanging tablets of sandstone, two hundred feet long, and thirty feet thick, projecting twenty feet beyond their supporting cliffs, and a hundred and fifty feet above the spectator's head; dark forest gorges, heading up in caves, over the roofs of which fall high cascades; and in the decomposable faces of the cliffs, bear-dens, and robber-caverns, and pit-holes of all sizes, sometimes so numerous as to give the traveller the impression that he might make out old inscriptions, with a genuine meaning in them, if he tried.

From the disintegration of this world of friable sandrock, from the slow cutting of the waters of all the forks of Paint, down through from 200 to 250 feet of such strata, in the lapse of geological ages, have come the incredible quantities of loose, yellowish sea-sand, which form the terraced banks of the Sandy River, fill up its valley-bed, and give to it its name.

There are other similar sandrocks,* running horizontally

* On Low Devil Creek, a head of Red River, at the 236th mile of the Base Line Survey, and therefore 50 miles west of Paintsville, the Tionista (Freeport?) Sandstone lies 80 feet above the Conglomerate, and is well filled with plant impressions, and has thin coal-seams wedged in between its layers. S. S. Lyon, IV, p. 532.

through the hillsides, higher up in the coal measures, and forming crags and cliffs, caves, tables, pulpits, and ship rocks, of the same picturesque pattern; but they are comparatively thin, and of small account compared with the vast stratum through which the cañons of the Upper Paint waters have been excavated; as the cross section (Fig. 1) will best show. Nothing, in fine, is more remarkable about these waters than the absence of boulders and fragments of rock in the beds of the ravines, the smoothness and gentleness of the main streams, and the incredible abundance of sea-sand; and that these features should coexist with the presence of lofty cliffs on every side, from which it would naturally be expected that thousands of fragments would fall and encumber the slopes. But, on the contrary, the homogeneous and friable nature of the strata has permitted the ordinary meteoric agencies, rain, frost, sunshine, and wind, to wear them down piecemeal, powdering up whatever dêbacle occasional uncommon storms might produce, and passing off the entire debris into the lower country of the Sandy and Ohio rivers. For there is no evidence that glacial action has ever had a hand in forming this topography.

Fig. 1.

The Coal Measures of the Paint Lick country contain at least four coal-beds; one of them underlying the Conglomerate, and the others overlying it. They are none of them large, but they will serve the purpose of local consumption; and, when fully explored, may prove

to be much larger and better than is now known, for the country is in so wild and undeveloped a condition, and the coal-beds of the Lower Coal Measures, to which these beds belong, are so variable, that they may be expected to present different aspects of size and quality on every different hillside.

The following scheme of the beds, showing their Kentucky and their Pennsylvania names in opposite columns, will be useful to enable one to understand them without confusion:

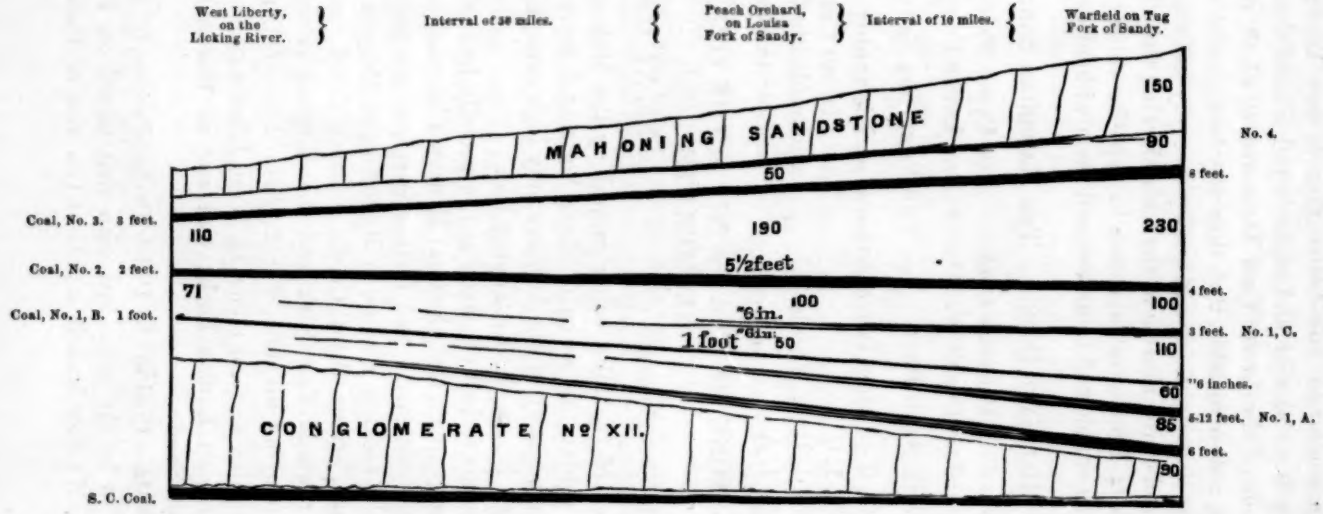
Top Hill Sand Rock	= The Mahoning Sandstone.
Coal No. 4 = Pomeroy Coal	= Upper Freeport Coal.
Coal No. 3 = Coxe's W. Liberty	= Lower Freeport Coal.
Middle Sand Rock	= The Freeport Sandstone.
Coal No. 2 = Main Peach Orchard	= Kittanning Coal.
Coal No. 1, C	= Clarion Coal.
Coal No. 1, B = Wheeler's ?	= Brookville Coal.
Coal No. 1, A	= Tionista Coal.
MILLSTONE GRIT = No. XII	= THE GREAT CONGLOMERATE.
Coal Sub-conglomerate;	= No. XI. Coal.

A few of the hills, being capped by the Mahoning Sandstone, contain all seven of these horizontal layers of coal; but the majority of the hills are only high enough to take in Coal-bed No. 2, the Kittanning bed.

It seems to be well made out, especially by the labors of Mr. Lesquereux, that the Coal Measures become thicker, and the coal-beds larger and farther apart, as one pursues them from the Licking Waters, in Magoffin and Morgan Counties, eastward, across Paint Creek, Jenny's Creek, and Louisa Fork, towards Tug Fork and the Virginia country. The accompanying diagram, Fig. 2, gives three of Lesquereux's comparative sections: one at West Liberty; one at Peach Orchard, on Louisa Fork; and one at Warfield, on Tug Fork of Sandy.

The Main Coal of the Peach Orchard mines, 5½ feet thick, seems to be the same bed with that mined on Paint Lick Creek, Wheeler branch, a mile or two west of Paintsville, at

FIG. 2.—EAST KENTUCKY COAL MEASURES.



an elevation of 195* feet above the creek, 4 feet thick (without parting slates), and dipping locally 2° towards S. 80° E.

About the other beds we know absolutely nothing at all, except that one or more of them becomes of great size (6 to 10 feet thick) in the neighborhood of Prestonburg.

The Sub-conglomerate Coal, which is a respectable 4-foot bed in Middle Kentucky,† crops out all along the foot of the Conglomerate cliffs, in the cañons of Upper Paint Lick waters, just above water-level, and of variable thickness, being sometimes only a few inches thick, sometimes yielding two feet of coal, and sometimes showing an outcrop of mere black slate, three or four feet thick.

This is, perhaps, the 6-inch bed of coal which the three wells at Lyon's Steam Mill, at the mouth of Open Fork, are said to have passed through, not many feet beneath the water-level; but I think it more probable that it is a second and lower bed belonging to the Sub-conglomerate System, but of still less practical importance.

A bed of iron ore (blue carbonate of iron) everywhere accompanies the coal and black slate just under the Conglomerate Rock. But this, also—although well developed in Middle Kentucky,—seems to be of small importance on Paint Creek. Near the Lyon Well I saw it as a stratum of balls, 2 to 4 inches thick, enveloped in shales, and lying about 5 feet below the bottom plate of the Conglomerate.‡ The shales are themselves ferruginous, and bog iron-ore springs issue from the edge of the stratum, in many places, forming puddles of yellow slime, which the people call sulphur, but which is merely iron-rust, commonly mixed, also, with oil.

* Kentucky Reports, Vol. I, p. 210.

† See Joseph Lesley's Report in Kent. Rep. Vol. IV, p. 474. The bed near Proctor, Owsley County, is 42 to 50 inches thick, and is one of a system of Sub-carboniferous Coal Measures, consisting of five (5) beds.

‡ Some charlatan had given the neighbors to believe that it was an ore of platinum. Just as Owen describes, "the Swift mine" of silver, near the Tennessee line, as turning out, on examination by him, to be merely dark gray kidney clay ironstone. Vol. I, p. 222. In Estill County, the ore varies from 7 to 24 inches, but rests directly on the sub-carboniferous limestone. Vol. IV, p. 471.

There are two other places for iron ore in the series, but they have not been explored in this neighborhood. *The Buhrstone Ore* of Clarion and Venango Counties, in Pennsylvania, and of the Hanging Rock Region of Ohio, and of Grayson and Carter Counties, in Kentucky, ought to come in between Coal-bed No. 1, C, and Coal-bed No. 2. But the Kentucky geologists conclude from their observations, that this remarkable deposit did not extend itself so far south in this direction.

Another bed of iron ore, however, exists on the hills on the east branch of Jenny's Creek, which probably spreads itself more or less through all the hills of the country. It underlies 30 feet of sandstone and 2 feet of shale; and it consists of a roof of pyritiferous sandstone, 8 inches; black bituminous shale, 1''10; iron ore, 2 to 4 inches; coal, 2''6; underclay, 1 foot.* The inclosure of the iron ore between two bituminous beds, is not favorable to its quality. This is probably the same ore stratum which underlies the Top Hill Rock (Mahoning Sandstone), on the Licking waters,† and the Red River branches, where it is from 18 to 20 inches thick, and of good quality.‡ The situation in the series is precisely that occupied by the Summit Ore stratum of Armstrong County, in Pennsylvania. It deserves to be carefully studied.

Petroleum is the mineral that excites most interest at present in all this region, and the show which it makes upon the surface is extraordinary. It issues in numerous places from the base of the cliffs which form the walls of the cañons through which flow the main Paint and its many branches. It saturates the slopes and banks of loose sand. It flows off, when the sand is stirred with a stick, as a shining scum upon the surface of the stream. It has been caught against booms and barrelled for sale. It unites, also, with the sweepings from the Sub-conglomerate ore and coal shales, and forms slimy ore bogs and muck heaps, where the base of the Con-

* Lyon's Report, Vol. IV, p. 543.

† Idem, p. 538, 537.

‡ Idem, p. 535.

glomerate is at any greater height than usual above the water-bed, and the slope from it is, therefore, longer than usual. Such is the case at the Old Oil Springs, on the north line of the May & Ross Survey, where it crosses the Oil, Little or South Fork of Paint; and again 200 yards lower down, at Pendleton's Oil Spring.

A black reservoir of tar-like oil here occupies the centre of a sloping bog, and is kept always full from a spring at its upper limit, near the top of the slope and the foot of the cliffs, about 20 feet above the level of the stream. Figure 3 shows the conformation of the ground; *a*, the spring; *b*, the reservoir; *c*, the bed of Paint Creek.

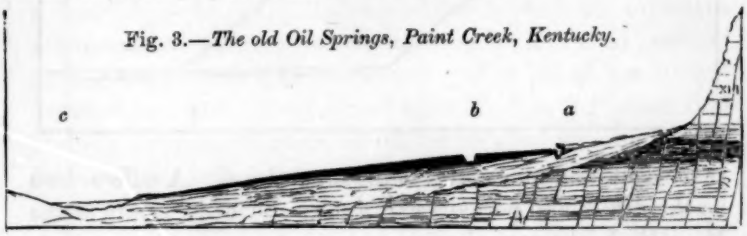


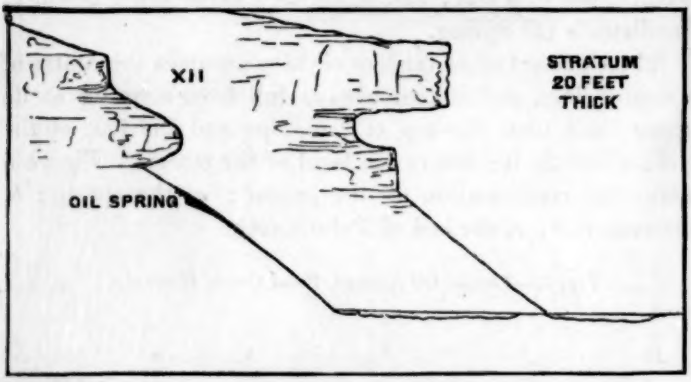
Fig. 3.—*The old Oil Springs, Paint Creek, Kentucky.*

A mile further down the stream, but on the opposite or right bank, and apparently 35 or 40 feet above the water, on a steep slope, close under projecting cliffs, is a similar spring, which has not produced any extensive bog, for want of a level receptacle, but which has yielded "large quantities" of oil in past years, and from which the petroleum continues to run slowly all the time. Fig. 4 shows the contour of the ground and the overhanging cliffs, at two places near the spring.

Three miles further down the stream, and within a mile or less of its junction with the North or Open Fork, at Lyon's Well, the oil is to be seen coming from the edge of the coal- and ore-shales, just under the cliffs, which here tower to an amazing height, especially upon the west, or Emigh Survey side; the survey cornering upon the stream close by, at a stump, at the mouth of a little run. Fig. 5 represents, in a formal manner, this section, and a pile of Conglomerate crag, called the Crow's Nest, between one and two hundred feet high, wonderfully tower-like and regular, opposite.

There are here, immediately underneath the lowest plate of Conglomerate (20 feet thick), 5 feet of shales, then two feet of yellow sandstone, then 1½ to 3 inches of ball ore,

Fig. 4.—*On Little Paint Creek, Kentucky.*



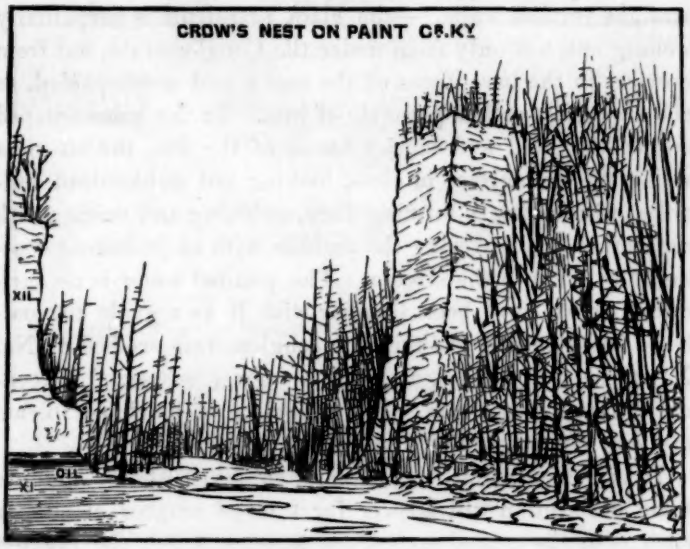
then black and blue slates to the creek level. A mile or two up the creek, and perhaps half a mile above the mouth of the Mine Fork, there are in these black slates two distinct beds of coal, 6 feet apart: the upper 10 inches, the lower 24 inches thick; and oil flows from them continually in small quantities. The extraordinary erosion of these valleys could not be studied anywhere to better advantage than at the junction of the Mine Fork with the South Paint. The topography is exactly reversed. The nose of rock making the fork, itself one of the most romantically picturesque piles of pulpit rocks to be found in the United States,* points up stream instead of down, the tributary Mine Fork meeting the main stream fair in the face. (Fig. 6.)

From the Crow's Nest down to the Lyon Well, and further on down the Main Paint, the same appearances repeat themselves. Here are to be seen the old "stirring places," where, before the rebellion broke out and put an end to all manner of trade in Kentucky, Mr. George and others collected oil

* I have given the crag at this point the name of the Propylon, because of its remarkable likeness to that feature of Egyptian architecture.

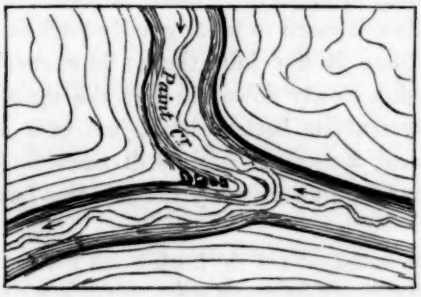
from the sands, by making shallow canals one or two hundred feet long, with an upright board and a reservoir at the lower

Fig. 5.



end, from which they obtained as much as two hundred barrels per year, by stirring the sands with a pole. The same

Fig. 6.



method has been employed, with like success, as far down Paint Creek as the cliffs continue high; that is, to within six or eight miles of Paintsville.

At Davis's, where the road crosses Paint Creek, just below the mouth of Little Glade Run, and in the midst of the finest cliff scenery,—the Conglomerate being here 230 feet thick, and the streams flowing at the bottom of it, between long straight vertical walls,*—the black petroleum is perpetually welling out, not only from under the Conglomerate, but from crevices in the bare faces of the rocks, and accompanied, as elsewhere, by yellow peroxide of iron. In the holes scooped out of the sand and mucky banks of the run, the oil rises visibly to the surface in clots, looking not unlike dead tadpoles, which, slowly forming discs, widening and uniting with each other, and covering the puddles with an iridescent coating, flow off into the stream. The painted water is no curiosity, for we have been familiar with it as a guide to coal-beds, and especially to the Sub-conglomerate ore-bed of No. XI, these many years, although we never suspected its connection with petroleum. But the clots of black petroleum are very curious and characteristic.

It is evident, from the description given above, and the same description will answer for a large number of similar springs in the numerous gorges through which the Licking waters find their way westward into the Blue Grass country of Middle Kentucky, that the petroleum of the oil springs of Paint Creek has had its home in the great Conglomerate at the base of the coal-measures; *still has*, we may say; for it is still issuing, in apparently undiminished quantities, from the same. How it came to be originally packed away there; how long a time it has lain there; how much of it has managed to sink slowly down through the mass, and collect itself as a layer at its bottom level, just over or in the ore and coal-shales; how much of it still remains disseminated through the mass; how recently the streams have succeeded

* Some of the walled sides of the Little South Fork of Red River are said to be impracticable for seven miles, where it is walled in, nearly perpendicularly, to the height of 200 to 300 feet without a break. The head of the Hotel branch of Graining Block Creek terminates abruptly against a cliff 250 feet high, the chasm being about the same width. S. S. Lyon's Report, K. R. IV, p. 531; 229th mile Base Line Survey.

in cutting down their cañons to the bottom of the sand mass, so as to afford an exit for that proportion of the petroleum which had there collected to begin its escape; how far the petroleum, in its downward progress, has passed through the ore and coal-shales, and has found still lower horizons to stop it, and is there waiting for the oil-well borers to come and give it issues to the surface; and to what extent, on the other hand, the deeper and older petroleums (of which I shall speak hereafter) have found fissures from below, up which to ascend to mingle with this petroleum of No. XII: these are questions of the greatest practical importance, which no one, so far as I know, has distinctly stated; and they can only be fully answered after long practical investigation.

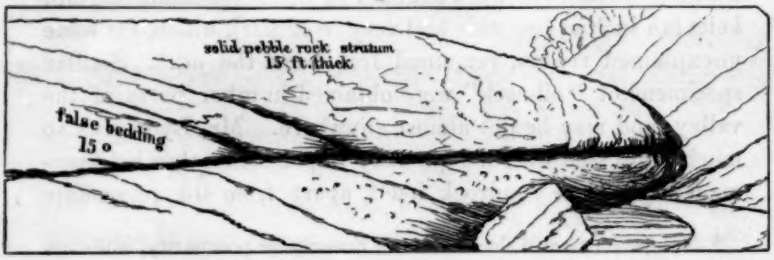
A Conglomerate age or horizon of petroleum exists: this is the main point to be stated. It must be kept in view apart from all other ages or horizons of oil, whether later or earlier in order of geological time. I have no doubt that some of the petroleum flowing or pumped from old salt wells in Southwestern Pennsylvania comes from this horizon of No. XII. The rock itself is full of the remains of plants, from the decomposition of which the oil seems to have been made. I noticed in the great rock pavement, at the Lyon's Well, over which the creek water flows, many sections of tree branches and stems, mashed flat, each section being, say 6 inches long by $\frac{1}{8}$ inch wide in the middle; and when a jack-knife was thrust down into the slit, so as to clear it of mud, the black tarry oil would immediately exude and spread itself over the water. A pointed hammer spalling off flakes of the rock on each side, showed not only that the slit itself was full of thick oil, but that the whole rock was soaked with it, except along certain belts (an inch or less wide and very irregular), which, for some unexplained reason, remained free from the oil.* Similar specimens of "oil-rock" were obtained in other parts of the valley, and may be got almost anywhere. Mr. Lyon was so much impressed with the quantity of petroleum thus held permanently by the sandrock itself, apart from the immediate

* My specimens still show this very remarkable peculiarity, although I have had them in a dry, warm room for weeks.

presence of the plants, that he actually erected a powerful rock-crusher, and sunk a shaft, by blasting 38 feet, intending to drift in the directions in which he found the saturation to prevail, and to distil the rock after it had been reduced to powder. Of course such a project was most unprofitable; but it well illustrates the abundance of the petroleum held by the friable sandrock. Some of the great blocks of rock which have fallen from the cliffs too recently to be as yet decomposed, are literally full of the marks of the broken macerated driftwood of that period. For hundreds of square miles this vast stratum of ancient sea-sand is a thick packed herbarium of coal-measure plants. My brother, in his report of the counties further west, writes:* "Thin streaks of coal are jammed in between the layers of the base of the Conglomerate, and even inlaid in the heart of the solid rock, all along the line." But if the loose sands of the banks of Paint Creek, derived, as they are, from this sandrock, can at the present day receive and retain vast quantities of petroleum, in spite of the perpetual washings to which they are subjected, we can easily conceive of the wide, flat sandy shores of the coal islands of the ancient Archipelago of the coal era becoming completely charged with the decomposed and decomposable reliquiæ of both the plants of the land and the animals of the sea.

The Conglomerate is very irregular in its internal composition, or "false-bedded," even to angles of 15°, or more. Instances are given below, taken from near Davis's House. Under the rock in Fig. 7 Davis's principal oil

Fig. 7.

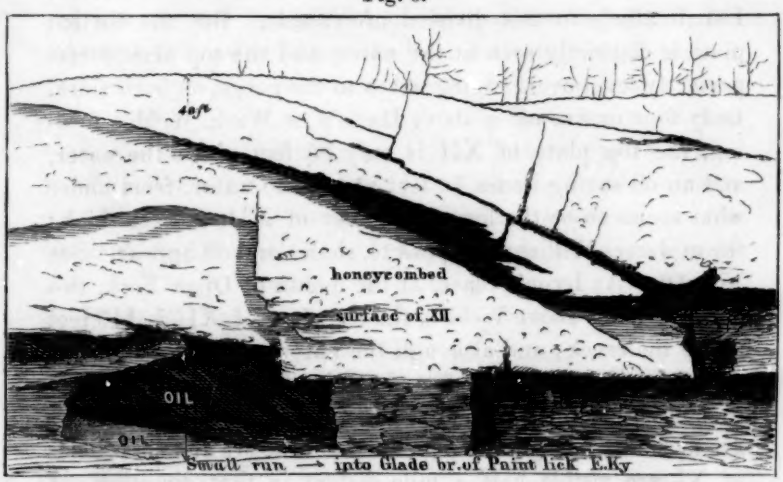


* K. R., Vol. IV, 1858, p. 454.

spring issues, as shown in Fig. 9; it formerly oozed from x. The whole lower, shadowed, or overhung portion of the rock, in Fig. 8, exudes oil from its false-bedding joints, as if these surfaces had received and preserved an extra quantity of the organic matter.

The Conglomerate is, however, still more irregular in the thickness of the whole mass, as was demonstrated on a large scale in 1857 and '8, by Joseph Lesley's survey of the west edge of the coal area, from the Ohio River to the Tennessee State line. He carefully measured the thickness of the sand-rock No. XII, and the shales below it, No. XI, in every county through which the survey passed. On the Ohio River, XII is 90 feet thick, over a few shales, with a thin coal-bed. On the North Fork of Licking, XII is 150 feet thick, over only 8 feet of shales, "with a well-defined bed of iron ore and a foot of coal." On Miner's Fork, 148 feet of XII lies directly on the limestone. In Estill County, XII is 196 feet, over 50 feet of XI shales, with a workable ore-bed and 27 inches of coal. At Standing Rock, XII is 210 feet, over

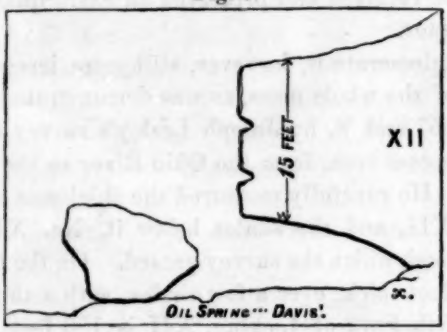
Fig. 8.



50 feet of XI. From this on, southwards, XII is never over 80 feet thick, while the XI shales increase to 225 feet, with two workable and three thin coal-beds, with three distinct ore

shales.* At Proctor, XII is only 60 feet, while the XI shale mass is even 296 feet thick.†

Fig. 9.

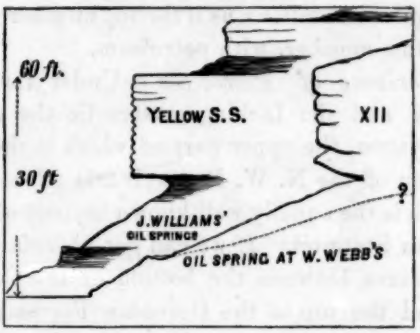


Now I measured the cliffs on Paint Creek in many places, and found the most striking variations. At Davis's, XII is 230 feet thick, the whole of it visible, in a wall composed of two members. Sometimes an upper unbroken wall, of 50 or 60 feet, is retired a little behind the lower and still more massive wall, which rises directly from the bed of the stream. I shall allude to this division afterwards. But the bottom plate is distinctly seen at the water, and the top plate forms perfectly level overhanging eaves to the gorge, on both sides. Only four or five miles above Davis's, at Wash. Webb's fording, the top plate of XII is only 85 feet above the water, and an oil spring issues 10 feet above the water, from under what seems to be the lowest member of XII, 30 feet thick; for at James Williams's, opposite, shales and oil appear. See Fig. 10. At Lyon's place, at the mouth of Open Fork, two or three miles above Webb's, the top plate of XII is 140 feet above the creek; and although the water runs over sandrock, yet shale is struck a few feet down in the well, and the subcarboniferous limestone at a lower depth; while the rocks are normally horizontal up stream, and the ore and coal shales of XI are visible half a mile distant in that direction. I have not the least doubt of the rapid variability of No.

* Kentucky Report, Vol. IV, p. 454. † Idem, p. 478.

XII. And this accounts for the great variations in the aspect of the valley at different places, the appearance and disappearance of cliffs, the commencement and termination of

Fig. 10.



cañons, and the alternate ascent and descent of the margin of arable land upon the hillsides above.

Oil wells, then, if bored in the Paintsville country, or in the upper parts of the valleys of the Paint Creek waters, on the Lewis Survey, cannot calculate on any fixed thickness of No. XII to go through. They may find this mass of sandrock 50 feet thick, or 250 feet thick; and the difference must materially affect their production of oil, supposing the oil to reside in this sandrock, or to be collected at its base.

The division of No. XII into two numbers is also important, because this ought to give two horizons of petroleum instead of one. It is remarkable, that all through Pennsylvania the Conglomerate (No. XII) shows a tendency to subdivision into two or more massive sandrock members, separated by somewhat softer or even soft shaly formations. It is evidently a general feature of its character, produced by some universally acting, still undiscovered cause. But one of its effects is to establish a second line of oil springs at a much higher elevation in the cliffs than the one I have been describing. At Davis's, where the upper member of XII is retired a hundred yards or so, at the top of an intermediate slope, the oil is said to exude at all times as abundantly from

the base of this upper member as it does from the base of the lower member. This is at an elevation of at least 150 feet above the creek.

So, also, under the numerous cascades which the top plate of the upper member of XII makes, for miles up the valley, there are similar exudations, as if the top member was charged, like the bottom member, with petroleum.

Lower Horizons of Petroleum.—Under the country of Paint Creek and the Licking waters lie the rocks of the Devonian System, the upper part of which is the well-established horizon of the N. W. Pennsylvania oil, and the lower part of which is the equally well-known horizon of the Canada and Michigan State oil. If we can get, therefore, the thickness of measures between the bottom of the Conglomerate, No. XII, and the top of the Devonian Formation, and also the thickness of the Devonian Formation itself, we can approximate to the calculations of the normal depth of oil wells, if bored to reach, first, the Pennsylvania oil, and secondly, the oil of Canada.

This, then, is the first question:—How deep should the Lyon Well, or the Hinckley Well, or the Spradley Well, or any other well starting from the bottom of the Conglomerate, descend, to strike the upper face of the Devonian Sandstone; and how much deeper must it continue to go to reach the Blue Limestone on which the Devonian System rests? When this first question is answered, it does not follow that the oil will be struck at precisely those places in the Devonian System at which it is struck in Pennsylvania, Virginia, or Canada; for that would depend on the continuance, over immense distances, of certain individual oil-bearing rock members of that system. Thirdly, The quantity of oil at any such level will be a local peculiarity, dependent *originally* on the local abundance of organic matter, both animal and vegetable; and, *secondarily*, on the local thickness, coarseness, and general fractured condition of the oil-bearing rock.

To answer this question, it is necessary to state the order of the formations, as follows, descending:—

XII. Conglomerate Sandrock.
XI. Sub-conglomerate, or Lowest Coal Measures.
XI. Sub-carboniferous Limestone.
X. Upper Devonian (Catskill) White Sandstone.
IX. Upper Devonian Red Sandstone and Shales.
VIII. Middle Devonian (Chemung) Clay Sandstones.
VIII. Lower Devonian (Portage, Hamilton, and Upper Helderberg) Olive Shales and Black Slates, viz.:
Genesee Slate;
Tully Limestone;
Hamilton Slate;
Marcellus Shale;
Corniferous and Onondaga Limestone;
Scoharie Grit;
Cauda-galli Grit.
VII. Oriskany Sandstone.
VI. Upper Silurian (Lower Helderberg) Limestones:
Onondaga Salt Group;
Galt Group;
Niagara Group.
V, IV, III, II, I, it is not needful here to specify.

Enough has been said, perhaps, respecting the Conglomerate; and respecting the No. XI Ore and coal-shale system under it.

No. XI Limestone is the next important formation to consider. Just the reverse of No. XII, and the other sandstone formations, which have their greatest thickness along the Atlantic seaboard, this "Sub-carboniferous Limestone" of the Great West *thins away eastward* (or northeastward) almost to nothing; is scarcely 10 feet thick where it enters Maryland, and not 2 feet thick in Eastern Pennsylvania. But in Southern Virginia it is quite large; and in Middle Kentucky it is twice as thick as No. XII, but, like it, subject to great variations. Only 70 feet thick on Tygert's Creek in Greenup County on the Ohio River, it increases to 400 feet in Clinton County on the Tennessee State line. It is composed of alternating white, gray, and buff-colored layers of rock, varying in quality from the most argillaceous claystone to the

purest limestone. Its lowest strata contain, in many places, large dark green flint pebbles, which seem to have been extensively quarried by the aborigines. Traces of lead are found through its centre beds. The drainage through it is peculiar. The valleys excavated in it are dish-formed, broad, and shallow, and rarely have streams flowing through them; for the waters of the springs above are carried down through sinkholes and cracks in the cavernous limestone, and often reappear only to plunge again and again, before they finally gush out in copious, clear, and never-failing springs, along the junction of its base with the next underlying Knobstone formation, near the mouths of the valleys, as they open towards the Blue Grass country. We have thus valleys which are technically dry, the bottom being a mere series of dry, crater-shaped holes, where cattle graze.* In Bath County (70 miles west-northwest of Paintsville), the valleys are terraced with two lines of springs, an upper line of warm soft water coming from the coal shales under XII (85 feet thick), and a lower line of cold hard water, issuing from the base of the XI limestone,† 140 feet thick. In Powell County (60 miles west of Paintsville), the limestone is thick and cavernous; sinks and caves are seen on every hand; the cavern roofs fall in and let down the upper ore and coal measures, so as often to baulk the miners of their bed, over large areas.‡ On Rock Lick and War Fork, in the north corner of Jackson County (about 45 miles W. S. W. of Paintsville), the great thickness

* Copied in substance from J. Lesley, Ken. Rep., IV, 452.

† Idem, p. 466, 467. See, also, the description under the head of Rockcastle County, page 482.

‡ Ken. Rep., IV, p. 472. Between Roundstone Creek and Kentucky River Valleys, in Rockcastle County, where the Conglomerate XII is very thin, and only in fragments on the upland, a remarkable number of holes occur in it, only to be accounted for by reference to the cavernous nature of the underlying limestone, on which it almost immediately rests, the shales of XI having run down from 240 to 40 feet. The No. XI limestone measuring variously 115, 145, 182, 220, and 240 feet, the last in the southeast corner of the county. The "cavernous" member of XI is described as being about 100 feet down from the top of the limestone. I think it possible that the downthrow (of XII) of 150 feet at Davis's Fording may be due to the same cause.

of both the XI Shales and the XI Limestone will be apparent from the following section:*

Fig. 11.

It might be argued that this limestone formation is not itself much, if any, concerned in the question of oil, from the fact that the formation is absent in the oil districts of the Ohio River on the Pennsylvania State line; as well as from the fact of its clayey and cavernous constitution, no oil horizon being as yet known in common clay rocks, nor any positive proof having been yet afforded of its collection in caverns so extensive and communicative, and so well drained as those which characterize this formation. But on the other hand, it may be urged: 1, that we do not know to what extent the formation of caverns in it may be confined to the belt of country in which its outcrops permit the cavern-producing waters to escape with their dissolved material; 2, that the Rathbone Well, in Virginia, 700 feet deep, and the Lyon Well, now to be described, both penetrate the limestone, and find in it flows of oil; and its crevices may, therefore, in some regions, play the part of the crevices in the sandrocks which yield petroleum; and 3, that it is crowded with animal organic forms, as can be seen from the following section copied from Mr. Lyon's Report, K. R., Vol. IV, p. 528.

Section obtained on the 218*th mile of S. S. Lyon's Base Line.*

		Feet.
XII.	Thick, remarkably false-bedded, fine sharp grit-rock, .	10
"	Thin-bedded, sharp grit-rock, ...	11
"	Whitish sandy shales, ...	22
XI.	Ore beds; and gray shales, ...	2
"	Thin-bedded, buff limestone, *indistinct fossils* rare, .	8

* J. Lesley, K. R., IV, p. 481.

		Feet.
XI.	Thin-bedded earthy limestone, *Retepora, Archimedes, Pentremites*,	2
"	Thick-bedded drab limestone,	13
"	? Aluminous and calcareous shales,	10
"	Flaggy, whitish oolite limestone; large *Pentremites pyriformis*,	10
"	Soft earthy buff limestone; irregular angular fracture,	11
"	Semi-oolitic crystalline limestone, producing red soil,	22
"	Rough concretionary blue-gray limestone,	10
"	Gray limestone with buff-colored segregations,	2
"	Bright buff earthy limestone; no fossils,	4
"	Irregular thin green-gray; no fossils; few chert beds at the top,	24
"	Thick-bedded semi-oolitic limestone; top, no fossils, segregations and beds of green flint; lower part, *Pentremites, Crinoidea, Bellerophon, Fish*,	22
"	Blue earthy limestone and shales, containing *Corals, Spirifera, Terebratula, Retepora, Crinoidea*,	38
"	Soft yellow earthy limestone,	56
X.	Soft greenish silicious shale (Knobstone),	32
"	Hard greenish silicious shale,	16
"	Hard fine-grained sandstone,	16
"	To the bed of Cow Creek, in all,	291

The Lyon Well was bored at the point of Paint Creek, where its South, or Little (Oil) Fork, and its North, or Open Fork, unite. The well-house stands on a plate of rock a few feet above the water-bed. A well was blasted through 20 feet of massive sandrock, under which the auger went down through 2 feet of shale, followed (at intervals not now remembered by Mr. Lyon, whose record of the well is lost) by micaceous sandstone, 33 feet of shale, blue sandstone, white marble, and blue limestone, to a depth of 213 feet.* Shows

* The men on the ground told me that 30 feet of blue slate rock was the first bored through, beginning, say, 10 feet beneath the bed of the creek; then a thin but very hard rock. They said that this Belt of slate was struck in the three wells on the creek above and below the Lyon Well, viz., the Donnell Well, bored 200 yards below the Lyon well, and 200 feet deep, the second Lyon Well, and the Warner Well, both near together, about half a mile up the Oil Fork, and 100 to 140 feet deep, quitting in hard rock. In the Lyon Well, they thought they struck a very hard thin rock about 140 feet down, and another 260 feet down, whereupon the auger fell 4 inches, and the gas blew the oil to the surface, and it began to flow. Such details from memory are worth little.

of oil were obtained at 124 feet, 160 feet, 193 feet, and 213 feet. The pump rods came up covered with oil as thick as softsoap, so that a pint of it could be scraped off at a time.* The oil obtained at 124 feet was of a specific gravity of 15°, while that obtained at 213 feet had a gravity of 30°.† The limestone and "marble" were tested with acids, and undoubtedly mark the place of the upper layers of the Sub-carboniferous Limestone of XI, which nowhere crops out to the surface in all this sandy country.‡

The depth of the S. C. Limestone below the Conglomerate may be stated, therefore, from the imperfect record of this well, to be 150 feet; which suits the recorded thickness of the Shales of XI, measured further to the westward. The thickness of the Limestone of XI may be reckoned at about the same; so that the Lyon Well would have struck the top of the Devonian Knobstone Formation, if it had been continued to a depth of from 300 to 350 feet.

It is as yet beyond our ability to distinguish the several original sources of the petroleum obtained at different depths from any one well. The specific gravities of the oil decreasing with the increase of depth, is a fact which shows conclusively that a chronic evaporation or distillation of the whole mass of oil in the crust of the earth (within reasonable reach of the surface) has always been and is still going on,§ converting the animal and plant remains into light oils, the light oils into heavy oils, the heavy oils into asphalt or albertite;

* I saw several barrels of oil in the well itself resting on the surface of the water. There are from 60 to 100 feet of pipe jammed in the hole, as it was dropped by accident when the well was abandoned on account of the unsettled state of the country.

† Mr. Lyon has been a distiller of coal oil, and had a distilling apparatus in his well-house, so that his testimony is entirely intelligent.

‡ It is, no doubt, the "Marble Limestone" of the main street of Mount Vernon, in Rockcastle County, a fine-grained white limestone, much esteemed by limeburners *there*, lying 40 to 50 feet below the top of the formation, and giving origin to a distinct horizon of springs. K. R, IV, p. 482.

§ See my paper on the Petroleum Vein of Northwestern Virginia, published in the Proceedings of the American Philosophical Society, Philadelphia, May, 1863, Vol. IX, p. 185.

the process being accompanied at every stage with the generation of gas. Therefore, the quantities of lubricating oil coming out from the Conglomerate, along the valleys of Paint Creek, prove the existence of immense quantities back from the cliffs in the rock itself, under all the highlands. And for the same reason, the heavy oils obtained first from Lyon's and Donnell's and Warner's wells, followed by lighter oils from a greater depth, prove the existence of yet uncalculated quantities of still lighter oils, at still greater depths; and of a world of gas-pressure which ought to make its presence known wherever there have been rents in the crusts, downthrows, fallings-in, or serious slopings of the stratification; in a word, any sort of natural vent.

Burning springs are instances of this very thing. One on Licking River, 4 miles above Salyersville, the court town of Magoffin County, and only about 12 miles in an air line southwest from the Lyon Well, has been celebrated since the settlement of Kentucky.*

Another still stronger burning spring exists at a distance of 35 miles in the opposite direction, one mile above Warfield, in the bed of the Tug Fork of Sandy, on the Virginia State line.†

* This Spring was described to me by Mr. Patrick, whose house (16½ miles from Paintsville by road) stands half a mile higher up the valley. It stands about 15 feet above water-level, in a dry place, the ground being burnt around it. The gas roared continually, and, when fired, would blaze 40 feet high. No oil was known there until a well was bored, from which the principal part of the gas now blows off, roaring and fluttering in it, so as to be audible for one or two hundred yards, scaring timid horses, before the well is within the rider's sight, and distinguishable by the smell for a quarter of a mile to leeward. The rock was found to be fissured in all directions to a depth of 3 or 4 feet, so that a knife could be thrust into the cracks. The auger went through about 150 feet of sandstone, &c., and is said to have got oil at every change of rock, and to have dropped 1½ inches at the end, where oil and water rushed up, so that from 500 to 1000 barrels were estimated to have run off per year. The rebellion put an end to operations. A second well was put down 100 yards distant down the stream, 130 feet deep, more or less, which got oil; and a third well at Patrick's house, 160 to 170 feet deep, which only got a small show of oil with some gas. These are the only wells in the county, except a fourth at the extreme west end of it.

† This Burning Spring is in 15 foot water, the whole of which is kept

These facts alone would suffice to prove the ground under the Paint Creek country charged with gas. But we have nearer evidence.

The Spradling Well, 4 miles up the creek from Paintsville, and 9 miles down the creek from Lyon's Well, on the Mud Fork of Paint, ¾ of a mile above its mouth, blows gas continually, which burns when lit.*

The whole of this section of Eastern Kentucky is, in fact, an underground oil region. Judge Harris's well, opposite Prestonburg, in Floyd County, 12 miles up Sandy River, above Paintsville, was bored about 600 feet deep for salt, and abandoned on account of the great flow of oil in 1845. The only record preserved was the fact of going through

in a state of ebullition by the gas, which, when fired, will blaze up as high as a man. When the stream is frozen over, holes are broken in the ice to fire the gas. Two wells have been bored in Warfield, 20 rods apart, in one of which the auger dropped 14 inches, at about 300 feet, six years ago, and the poles were greased with the ascending oil. The other well flows oil into the stream. Each gets salt water at about 800 feet. There seems to be a fault across the Fork, which throws the big coal-bed under for nearly 4 miles.

* D. D. Owen thus describes a burning spring in Clay County, in his Kent. Rep., Vol. I, p. 217, as "a constant stream of gas escaping in copious volumes through a pool of water, in a narrow bottom. A lighted match suffices to set the gas on fire, which flashes instantaneously into numerous jets across the pool, continuing to burn until the gas or a gust of wind blows it out. Judging from the color of the flames and the odor of the gas, it seems to be a mixture of heavy and light carburetted hydrogen with some free or uncombined hydrogen. The commotion in the water rendered it too turbid, without filtration, to test it satisfactorily for its saline constituents. Bicarbonate of iron seems to be its principal constituent. The gases must here reach the surface from some deep-seated source, through an extensive fissure of the rocks concealed by the debris from the hills,—perhaps from some bed of coal or iron ore exposed to surheated steam, or other heat. . . . The elements must be contained in the interior of the earth on a vast scale, since the Burning Spring has continued to evolve these gases with unremitting energy ever since the country was known to the first settlers." Through sand and shales of the coal measures, seven salt wells, yielding 130,000 bushels of salt per annum, penetrate to a depth of 1000 feet, getting brine at 121, 240, 293, and 552 feet; at which last depth the strongest is obtained, the auger dropping into cavities from which the brine, black with a carbonaceous sediment, gushes out, and afterwards grows clear.

black slate. Oil issued also from the Mayo Well, bored about 100 yards distant. These are the only wells in all that valley. On Shelby Fork, of Sandy, in Pike County, oil flowed from a salt well.

It is still doubtful whether the Knobstone formation which immediately underlies the Limestone, is the receptacle of this wide-spread petroleum, or whether we must seek the true horizon in the Blackslate formation which underlies the Knobstone in its turn.

No. X Knobstone formation (consisting of two parts, an upper Sandstone division, and a lower shale division) outcrops in a belt overlooking the Blue Grass country, and measures from 350 to 550 feet in thickness. The upper portion is a thin-bedded, olive-colored, generally fine-grained Sandstone, furnishing good grindstones sometimes, and always building-stone. The lower and larger portion is an olive-colored mud-rock, with pretty generally disseminated nodules of earthy iron ore, from which come most of the Chalybeate Springs of Eastern Kentucky. The upper member seems to correspond to No. X, and the upper half of No. VIII, in which lie the three oil sandrocks of Venango County, Pennsylvania (No. IX being entirely unrecognizable). But the difference of thickness throws us out of all our calculations; for these 350 to 550 feet in Kentucky stand as the representatives for at least 2000 feet in Northwest Pennsylvania, and for 12,000 feet in the Anthracite coal country. The Venango County First, Second, and Third Sandrocks, which have become so celebrated, occupy three horizons in the upper, or as perhaps we should rather call it, the middle part of VIII, lying at maximum depths of 200, 400, and 600 feet respectively beneath Oil Creek Valley bed, but 700, 900, and 1100 beneath the bottom of the Conglomerate, which there caps the hilltops on each side of the Valley. The section represented in Plate II will show this relationship of distances farther down the Alleghany River, at Brady's Bend, where the Conglomerate has reached the level of the Valley bed, and is, therefore, in the same relative position as on our Paint Creek waters. But if, as is pretty certain to be the fact, the Shales

of XI and the Limestone of XI, taken together, are only 300 or 400 feet thick, and the Knobstone is 350 to 550 feet thick, then the top of the black slates under the sandstone *might* be struck at the depth of the *First* Venango Sandrock (700 feet), and certainly would be at the depth of the *Third* (1100 feet), or even of the *Second* (900 feet).

It is evident, therefore, that all reference to the "Three Sandrocks" of the Oil Creek country is useless for countries to the southwest of it, and will be made only by those who are ignorant of the general bearings of the subject.

We can only say, that part of the 350 to 550 feet of Knobstone Form., X and VIII, represents the Oil Creek Formation, and, perhaps, contains one or more like horizons of oil; but whether in one, two, three, or what number of oil-bearing sandrocks, separated by oil-preserving shales, nothing but actual experiment can determine.

It is probable that the wells which penetrate the Limestone XI get their petroleum partly from the Conglomerate above, descending with the drainage waters. But it is still more likely that they get their principal amount of petroleum from the Knobstone Formation below, by a system of fissures similar to that of the Venango Oil region. In any case they are bound to prove productive; and I have not the least doubt that wells, sunk 600 to 800 feet along the Paint Creek Valley, will produce reasonably profitable amounts of Upper Devonian Petroleum, steadily, for an indefinite number of years; and this petroleum will be, of course, light oil, and not the heavy oil of the Paint Creek Valley surface.

The amount of petroleum capable of being held by rocks themselves is far greater than people imagine. They hold it in three ways: 1. By being more or less gravelly and porous throughout; 2. By being cracked in systems of cleavage planes throughout; 3. By being traversed by large fissures, which are, probably, all of them merely enlargements of cracks along the cleavage-planes.

Every foot of gravel-rock may be considered to consist of three-fourths quartz, &c., and one-fourth cavity, cleaned out by long percolation, and now occupied by water and oil.

The proportion which the oil bears to the water in the gravel is unknown, but must be far greater than in the 30 feet of sandrock (taking one of the Venango oil rocks as a base of calculation) at the top of which the gravel lies; for the oil will settle in these top layers of gravel, while the water remains in the body and lower layers of the sandrock. If the proportion in all be 1 to 100 (for the sake of the calculation), the proportion in the gravel may be 1 to 10, and in the few inches at the extreme top, even 10 to 1. If we should suppose only the uppermost four inches of the whole formation charged with pure oil, that would give an absolute layer of oil one inch thick underspreading the whole country as far as the sandrock extends, or about 4000 millions of square inches under every square mile, or, in other words, 17⅓ millions of gallons = 551,706 barrels. *Each sandrock* should be able to supply from *each square mile* of its area, the whole present oil produce of the United States for ninety days before it is exhausted, and that without any reference to the accumulation of petroleum in fissures.

Let us carry the calculation a little further, by taking now the fissures into consideration.

The Paint Creek country is one of the most undisturbed on earth. But the drying and hardening to which they are subjected through geological ages crack all rocks; and necessarily in three directions. Two of these directions are always and necessarily nearly vertical, one of them again, being the direction of the primary or master system, going down straighter and deeper, and giving origin oftener to large fissures and downthrows.*

* The downthrow at Davis's, the petroleum vein on Hughes' River, and other faults and fissures of magnitude in this part of the Bituminous Coal area, all belong to the same almost east and west system of cleavage-planes observable in the Alleghany River country.

In one great fissure (4 feet wide) of this east and west system on Hughes' River, the Devonian petroleum which underlies the Kanawha country (precisely as it underlies the Paint Creek country) has collected itself and hardened into asphalt, before the Kanawha valleys were scoured out. There stands this vertical, east and west running vein of solid petroleum, an evidence both of the abundance and of the antiquity

All clefts in sandrocks must, as a general thing, remain more or less open; and they are the great channels of rapid underground drainage. Fissures in shaly mudrocks are closed as fast as made by the plasticity of the mass, and by the perpetual percolation of fine clay into them. Those which penetrate coal-beds, for instance, are almost all filled up with clay from the overlying shales; while many of the fissures in the coarser sandrocks are only choked with loose sand or small water-worn pebbles. All these are permanent reservoirs of salt water and oil.

The law governing the number of these cleavage-planes is a simple one; the distance of the clefts from one another is, in the main, proportionate to the massiveness of the strata which they divide; that is, the cleavage-planes of the great beds of massive sandrocks lie much further asunder than those of the thin-bedded sandstones; while those subdividing beds of shale are still closer to each other and more numerous.

The law governing the size or width, and also the length and depth of the fissures, is an analogous one: the great sandrocks exhibit clefts sometimes many inches in width, and running many yards or hundreds of feet continuously. The pressure of these rocks sometimes carries their cracks down (or up) through the softer and thinner beds, and the strain of the dip will even cause these cracks to descend many fathoms below where they originated.

Some of the main fissures are known to be four inches wide. Suppose them to be of all sizes, from four inches to a quarter of an inch in width, and at various distance asunder, from 5 to 50 feet, and to be limited to the sandrock itself, say 30 feet in height; suppose we take the contents of the fissures equal to $\frac{1}{500}$th mass of the rock. Now, supposing the oil to occupy but $\frac{1}{10}$th of the space in each fissure, the rest being occupied by water and gas, we have a yield of oil

of the Devonian Petroleum. It contains at least 200,000 tons of asphalt (allowing it to go only 600 feet deep beneath the valley which it crosses); able to yield by distillation 178 gallons of refined oil to the ton of 2400 lbs., and therefore over *eleven millions of barrels* of refined oil; a quantity which would allow a Noble and Delamater Well to spout 6000 barrels per day for five years.

from each square mile of each sandrock, in addition to that above, amounting to nearly 50,000 barrels of oil. This is at the lowest calculation. In the case of a well yielding one or more thousand barrels of oil per day, for a year or years, we have only to imagine a single four- or five-inch fissure crossing the upper and lower rocks to a height or depth of one or two hundred feet, and extending a mile or two in length, the oil contents of which will amount to millions of barrels, apart from all side supplies. Along the line of one such fissure, it is easy to see that a dozen first-class flowing wells might last for several years. By ordinary wells it would be practically inexhaustible.

It is not upon these exceptional fissures that the future trade will rely; but upon the myriads of cleavage-planes and cross-cracks which break up the whole crust into cubes, so far as it consists of sandrocks. The number of grand open fissures must be very small; the number of first-class flowing wells is as yet extremely small,—one or two dozen out of five or ten thousand wells in the Oil Creek region. I judge that not more than one well in ten or twelve yields more than one barrel of oil per day. The large majority of the wells must necessarily depend for their supplies upon the slow circulation of the mingled fluids, salt water and oil, forever going on, exhausting and refreshing itself in the porous and cracked body of the sandstone formations. But in this very fact we have a guarantee for the genuineness of the area under discussion as an oil region, the certainty of obtaining petroleum by boring, and the protracted continuance of the supply for many years. All sand and gravel beds are mere sponges, perpetually saturated with oil and water, the mingled fluid being slowly driven towards every available outlet by the gas which is generated with and from the oil. Such spongy rocks must be enormous reservoirs of petroleum, which it is in fact almost impossible for man to exhaust, as I have shown above.

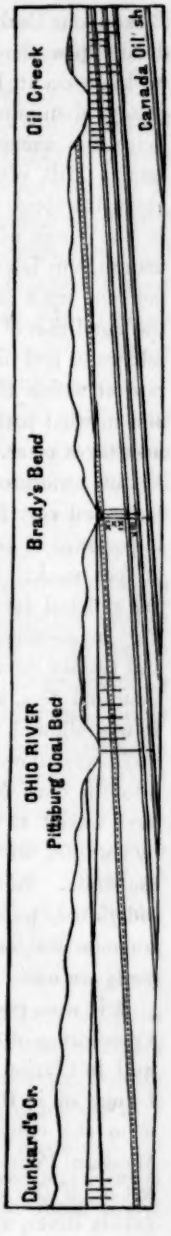
The Canadian petroleum occupies a still lower horizon than the Venango County petroleum, the distance between them in New York and Pennsylvania being variously estimated at from 2000 to 3000 feet. Its general relationship to the

higher horizons is shown in Fig. 12. The Venango oil rocks run up nearly a thousand feet over the level of Lake Erie; the black slates and corniferous limestone of the Canada oil come up from below the bottom of the lake to the north. Wells at Erie strike the oil at 900 feet.

But in Kentucky the black slates of the Canadian oil region underlie the Knobstone formation, and are, therefore, as I have shown, only from 650 to 950 feet beneath the Conglomerate in the bed of Paint Creek.

How far this black slate formation has supplied the Knobstone above it with petroleum, is a question that our science is not at present qualified to answer. But that it is a distinct horizon of oil every one grants. It has yielded copiously in Canada. Several wells, in Middle Kentucky, sunk in it, have yielded a constant flow.* It is in fact a great deposit of mud, charged with carbon to such extent that many of its layers will burn like coal, and even thin beds of true coal exist in it here and there. These are of course the remains of vegetation. But that they have furnished all the 5, 10, or 15 per cent. of carbon which we find in the formation, is doubtful, in view of the early age in which it was deposited, the abundance of animal life in the limestones under it and in some of its own layers, and the peculiar quality of the Canada oil which proceeds from it or from the limestone under it.

Fig. 12.



* In Estill County, one well was ruined by the force of gas. Another, bored by S. T. Vaughn, 405 feet, went through soil 15 feet, black slate 100, light clay limestone 100, gray limestone 190 feet, when the auger dropped, salt water gushed out, and soon gave place to the present constant stream of oil. K. R., iv, p. 472.

The total concealment of the Devonian system beneath the Great Bituminous Coal Area, renders it impossible to speculate with confidence upon the details of those changes in its constitution, which we know occur, in passing from its eastern outcrop (along the Alleghany Mountain) to its western outcrop in Ohio and Kentucky. With the exception of the two anticlinals of Chestnut Ridge and Laurel Hill, which, in their passage from Pennsylvania into Virginia, lift above water-level a few hundred feet of the top measures, in the Gaps of Two Lick, Yellow Creek, Black Lick, the Conemaugh, the Loyalhanna, and the Youghioghany, we are entirely dependent upon oil and salt well boring records for any knowledge of the condition of things in the Devonian underground; how far its salt water and oil-bearing sandrocks extend, each one for itself; the rate at which the intervals diminish in a west-southwest direction; and in what parts of the formation the greatest diminution of thickness takes place.

But, unfortunately, almost all the old records of salt borings are lost; and very few new wells have been sunk by men who knew the importance of keeping any other than a contract account for number of feet sunk. It is impossible to estimate the loss which geology has suffered during the last six years from this reckless ignorance. The inaccessible Devonian strata have been probed by between ten and twenty thousand augers, to depths varying from a hundred to a thousand feet, and no record kept of all that priceless information. It was allowed to flow off into the ocean of forgetfulness, as the oil itself was allowed at first to flow by thousands of barrelsful per day into the Gulf of Mexico. And even now, that men of intelligence have waked to the importance of the fact, most wells are still sunk by contract, without any provision for compelling a careful record of the strata. Nor is there any bureau in the State, any society, or any individual, publicly known to charge themselves with putting to common use, or even with accepting for preservation, what few records are made and kept.

It is with peculiar satisfaction, therefore, that I can publish in the Proceedings of this Society, an authentic record of the deepest recent well in Clarion County, Pennsylvania, and, in fact, the deepest that I know of in the country lying south of Oil Creek Valley. We owe it to the enlightened forethought of one of the master minds of Western Pennsylvania, Mr. Wm. M. Lyon, joint owner with Shorb & Co., of the large Rolling Mill on the south bank of the Monongahela River, and of numerous furnaces and forges in the middle

and western counties of the State. At one of these, Sligo Furnace, on Licking Creek, Piney Township, 10 miles S. S. W. of the county seat of Clarion, and 23 miles in a straight line S. S. E. of Oil City, a well was sunk for oil, which has reached the depth of about one thousand feet, passing through the following rocks:

Salt Well, Sligo Furnace.

			Ft.	In.
From surface to rock,		14,,	07	
Soft light-colored slate,		22,,	05	37,, 00
Black slate,		4,,	07	41,, 07
Hard sand rock,		7,,	05	49,, 00
Soft black slate,		6,,	00	55,, 00
Hard sand rock,		6,,	00	61,, 09
Sand rock and slate,		3,,	03	65,, 00
Coal,		1,,	09	66,, 09
Coarse sand rock,		2,,	00	68,, 09
Fine hard " "	XII	21,,	05	90,, 02
Coarse soft " " and water at 128 feet,		93,,	02	183,, 04
Hard slate,		10,,	00	193,, 00
Soft "		74,,	08	268,, 00
Soft red slate,		2,,	00	270,, 00
Soft sand rock,		10,,	00	280,, 00
Slate,		90,,	00	370,, 00
Close-grained blue sand rock, salt 38 per cent.,		20,,	00	390,, 00
Slate,		49,,	00	439,, 00
Hard blue sand rock and salt,		27,,	00	466,, 00
Soft slate, sooty substances, with smell of oil,		84,,	00	750,, 00
Soft red slate,		5,,	00	755,, 00
Hard sand rock [first Venango rock?]		10,,	00	765,, 00
Blue slate,		21,,	00	786,, 00
Red "		29,,	00	815,, 00
Blue "	IX?	77,,	00	892,, 00
Red "		2,,	06	894,, 06
Brown "		30,,	06	925,, 00
Alternately hard and soft slate, oil,		45,,	00	970,, 00
Slate,		22,,	06	992,, 06

Last boring done not measured. The hole is less than 1000 feet.

N. B. The mouth of the well is 175 feet below the Buhrstone Ore-bed level (all the rocks being nearly horizontal); below the ore, 30 to 40 feet, lies the Clarion coal; above the ore, 25 feet, the Kittanning coal; above this again, 50 feet, the general surface of the country.

Now it is evident that the mass of sandrock from 68.09 to 183.04, represents No. XII, the Millstone Grit, or Great Conglomerate, 116

feet thick, from the midst of which (128 — 68 = 60 feet below its top layer) there was a flow of salt water. The 74 feet of soft slate under it, and then 2 feet of red slate, seem to represent No. XI. There is no sign of the Sub-carboniferous (XI) Limestone of the West here; although no test for lime seems to have been thought of, and, therefore, the close-grained blue sandrock, 20 feet, may be calcareous. The "red slates," at 750 — 755, 786 — 815, and 892 — 894, look like representatives of Formation IX. The "hard sandrock," 10 feet, at 755 — 765, is the only one in the section which can be considered as occupying a position analogous to that held by the first sandrock of Oil Creek. It lies (755 — 183 =) 572 feet below the base of the Conglomerate (taken as above at 183), which is more than 100 feet less than its observed distance beneath the Conglomerate on Oil Creek; but the discrepancy may be accounted for *partly* by the extra thickness here of the Conglomerate. Neglecting the "sooty substance, with smell of oil" at 750, the first show of oil is at 970 feet, or (970 — 183 =) 787 feet below the base of the Conglomerate, corresponding to the Second Oil Rock of Oil Creek, which is about 900 feet beneath the Conglomerate. The place of the Third Oil Rock, and principal horizon of oil on Oil Creek, will, therefore, be at least 150 feet beneath the extreme depth to which this well has been sunk.

Mr. Lyon has furnished, also, a complete record of another important well, 891 feet deep, sunk into the extreme upper part of the Devonian Measures, on the Alleghany River, at Freeport, 25 miles above Pittsburg, and, therefore, 50 miles due south of Oil City.

Strata bored through in Salt Well, on Alleghany River, 25 miles above Pittsburg. Working coal stratum 3'6" thick in the hill, 35 feet above surface at the well.

		Ft. In.
Well, through loam and sand,	31,,00	
Rock, blue and hard,	0,,10	31,,10
Blue sand rock, with 8 to 10" iron ore,	16,,10	48,, 8
Gray sand rock, softer,	20,,06	69,, 2
Blue slate rock,	18,, 8	87,,10
Blue sand "	14,,10	102,, 8
Coal,	,,10	103,, 6
Fire clay,	6,, 8	110,, 2
White slate,	9,, 6	119,, 8
Limestone,	4,, 0	123,, 8
White slate rock,	3,, 0	126,, 8
White sand rock,	16,, 0	142,, 8
Blue slate "	3,, 6	146,, 2
Coal,	0,, 6	146,, 8

Fire clay, or white slate rock,		21,, 0	167,, 8
Blue sand rock, very hard and fine,		12,, 6	180,, 2
Blue slate " with balls of iron ore,		10,, 0	190,, 2
Black slate,		24,, 0	214,, 2
Blue slate harder,		5,, 0	219,, 2
COAL,		4,, 4	223,, 6
Fire clay,		6,, 8	230,, 2
Blue slate,		12,, 6	242,, 8
LIMESTONE,	F. L. ?	10,, 6	253,, 2
Fire clay,		7,, 0	260,, 2
COAL,		3,, 4	263,, 6
Fire clay,		2,, 0	265,, 6
LIMESTONE,		5,, 0	270,, 6
Fire clay,		1,, 6	272,, 0
Hard blue sand rock, fine grain,		9,, 6	281,, 6
White sand rock,	T. S. ?	37,, 0	318,, 6
Corrected measurement, for stretching and shrinking of the rope, to be added,		16,, 0	334,, 6
Blue sandrock, with nodules of iron ore,	XII ?	89,,10	424,, 4
Black slate rock,		10,, 2	434,, 6
Blue slate "		6,, 0	440,, 6
White sand,	XII ?	18,, 0	458,, 6
Blue slate rock,	XII ?	29,, 0	487,, 6
White sand,	XII ?	7,, 8	494,, 6
Blue slate, soft,		3,, 0	497,, 6
Gray sand rock,		4,, 0	501,, 6
Blue slate "		6,, 0	507,, 6
Hard gray slate rock,		19,, 0	526,, 6
Blue rock, 34'00''—very hard, 41'9'',		75,, 9	602,, 3
Gray rock,		39,,11	642,, 2
Black slate and COAL,		3,, 3	645,, 5
Gray sandrock,		3,, 9	649,, 2
Blue sand and white, very sharp,		8,, 9	657,,11
Gray sandrock,		9,, 0	666,,11
Blue sandrock,		3,, 0	669,,11
LIMESTONE,	S. C. ?	3,, 0	672,,11
Slate, and nodules of iron ore,		28,, 8	701,, 7
Blue sandrock,		21,,11	723,, 6
White slate,		10,,10	734,, 4
Blue sandrock,		79,,09	814,, 1
LIMESTONE (supposed),		7,,08	821,, 9
Blue sandrock, hard,		23,,10	845,, 7
White sandrock coarse,		4,,02	849,, 9
Blue slate,		4,,10	854,, 0
Blue sand,		10,,02	864,, 9
White slate, with iron ore,		11,,08	876,, 5
Light blue sand stone,		14,,08	891,, 1

In the above section, begun in the Freeport Series, it seems necessary to take the 10′6″ limestone at 242′—253′ as the Ferriferous Limestone of the Clarion Series, and the 37′ white sandrock at 281′—318′ as the Tionista sandstone. The Conglomerate, No. XII, will then be represented by the 89′ of "blue sandrock with nodules of iron ore," or the two "white sands" further down, or by both, in which last case, we have a total thickness of XII (494 — 334 =), 160 feet. From this to the bottom of the well is (891 — 494=) 400 feet; not enough by 200 or 300 feet to reach even the first of the Venango County oil sandrocks. But in these 400 feet we see black slate and coal (at 645), and limestone (at 672), apparently representing the sub-conglomerate coal shales and sub-carboniferous limestone of Kentucky, No. XI. Thick strata of so called "blue" sandrock, seem to take here the place of No. X; and the bottom of the well may, perhaps, with propriety be said to stop in the upper layers of VIII. Everything depends upon the rapidity with which the Devonian and Sub-carboniferous formations are thinning in their course, southwestward, from Northern Pennsylvania towards Kentucky. The coarse white sandrock at 845—849 must be observed.

It is at Tarentum, near this section, and on nearly the same level with it, that the old salt-wells were so much tormented with oil, that their proprietors contracted for its constant removal with Mr. Samuel M. Vier, of Pittsburg, seven years before Dwight struck oil at Titusville. From his skimming of these wells, Mr. Vier made what he called "carbon oil," which he refined by a process of his own, and sold quietly with the camphenes and burning fluids of the East, until it won the market. At first his oil was sold in twenty-five cent bottles as a medicine; and then as an oil for lamps. To Mr. Vier, who had made a large fortune, and retired from the field at its beginning, the oil-well excitement was, of course, a matter of great amusement. But the history of his process is the best illustration we could have of the permanent supply to be expected from those Alleghany River wells which penetrate deeply enough the Devonian measures.

Mr. Lyon furnishes the record of one more well still further south, and only 354 feet deep, and entirely in the Coal Measures, which, however, ought to be preserved, continuing, as it does, upward to the water-level at Pittsburg, our knowledge of the minutiæ of the Palæozoic column, from otherwise inaccessible depths, to where it can be studied in the open air. The absence from this section of any

thick coal-bed, corresponding to the large coal-beds of the Freeport series, is very remarkable.

Record of Boring at Superior Iron-works at Manchester, adjoining Alleghany City, opposite Pittsburg, McClure Township, Alleghany County, Pennsylvania.

Material.	Ft.	In.	Ft.	In.	Material.	Ft.	In.	Ft.	In.
Surface, . .	14		14		Blue clay, . .	13	2	187	6
White hard slate, .	10	6	24	6	Dark slate and fire clay,	9	10	197	4
Hard free stone, .	3	6	28		Dark slate, . .	2		199	4
Soft black slate or shale,	8		36		Slate and fire clay,	8	6	207	10
" with streaks sulphur,	14	3	50	3	Quartz, . .		1	207	11
Soft dark sandstone,	1		51	3	Slate with hard ribs,	8		215	11
Hard "	1	2	52	5	Hard white cry'd slate,	17		232	11
Dark slate, . .	9	1	61	6	COAL, . . .		10	233	9
Dark fire clay, .		9	62	3	Fire clay, . .	4	3	238	
Light slate, . .	3	2	65	5	Hard crystallized slate,	2		240	
Fire clay, . .		7	66		Soft fire clay, .	4		244	
Dark slate, . .	1	6	67	6	Soapstone, . .	5	6	249	6
Slate with hard rib,	9		76	6	Fire clay, . .	4	6	254	
Fire clay, . .	5	4	81	10	Hard clay rock, .	11		265	
Sandstone, . .	1	2	83		Dark slate, . .	9		274	
Fire clay, . .	7		90		Hard light slate, .	1	6	275	6
Blue slate, . .	2	10	92	10	Dark slate, . .	2	6	278	
Free stone, . .	2	2	95		Dark sandrock, .	3	6	281	6
Light blue slate, .	17	6	112	6	" hard and soft ribs,	4		285	6
Dark clay, . .	5	3	117	9	White sandrock, .	1	6	287	
COAL, . . .	1	9	119	6	Hard " .	2		289	
Blue clay or slate,	8	6	128		Dark " .	25		314	
Fire clay, . .	18		146		Wild coal, . .		4	314	4
Sandstone, . .	8	4	154	4	Black shale, . .	3		317	4
Fire clay, . .	2		156	4	Fire clay, . .	9		326	4
Hard sandstone, .	2		158	4	Slate, . . .	4		330	4
Poor iron ore, .		6	158	10	Dark clay rock, .	10		340	4
Dark slate, . .	3	6	162	4	Hard dark sandrock,	2	8	343	
Dark sandstone, .	10		172	4	Dark slate, . .	11	2	354	2
Very hard " .	2		174	4					

Mr. Chase has obtained the following record of a Salt Well bored in 1840–1, at Latrobe, in Westmoreland County, on the Pennsylvania Railroad, 30 miles east of Pittsburg. It is called Saxman's Salt Well, and has been long abandoned. The Pittsburg Coal-bed, 8 feet thick, lies 10 feet above the level of the mouth of the well:

Soil, &c., ...	15 feet.	
Slate rock, blue, soft, ...	1	
Sandrock, blue, close, 3; somewhat softer, 3, . . .	6	
Slate rock, sandy, blue 2; slate, blue, 5, ...	7	
Sand rock, blue, 7 (white flint 2 inches), ...	7	
Black, slate-like COAL, 1"10, ...	2 =	38
LIMESTONE, with some ore and mud veins, . . .	19	
Slate and sandrock, mostly blue, some almost black, silvery sand came up, *gas vein struck at* 85,,10, *which boiled for two hours and then stopped*, ...	69 =	126

COAL, "8; black slate, "20; black limestone, "20; black slate, 3; dark limestone, 1; 8
Slate, blue, 5"8; limestone, 1; 7
Sandrock, hard, 5"4, ... 5 = 146
Sand slate, blue, 40; sandrock, blue, soft, 8; hard, 12; hard and black, 13; dark blue, 10 (*gas vein struck at* 229"2, *strong*); coarse-grained, blue, soft, 1; blue and shaly, some black specks, 29, ... 113 = 259
Slate, hard, blue, rocky, 9; soft, blue (some black), 26, . 35 = 294
Sandrock, dark blue, hard, ... 4
Slates, blue, brownish, and black, some like hard coal, . 28
Slate, blue mixed with limestone, ... 2
LIMESTONE, hard, free, with some sand, ... 5 = 333
Slate, blue, 4; *red, like kiel*, 14; soft blue (soapstone), 5; dark, some sandy, 11; . . . . . 34 = 367
LIMESTONE, black, mixed with ore, ... 1
Slate, dark blue, sandy, ... 2
COAL, "16, ... 1
Slates, blue, some sandy, 37"8; blue and *red*, 2; *red kiel*, soft, 15; blue, becoming sandy downwards, with some hard layers, 11; and *some salt water* at 430 (at 428 hard shells, resembling white flint), ... 66 = 437
Slate, sandy, hard, blue, ... 16
Sandrock, soft, *almost black*, 8; close-grained, hard, blue and black, 23; very hard, blue (the hardest yet struck in the well), 4; *salt water increasing gradually from* 465 *to* 475 *feet*, 35 = 488
Slates, blue and black, with two thin layers of hard sand, 12; alternations of slates and sandrocks, 15; sandrock, blue, with hard shells, 6; . . . . . 33 = 521

This should bring us nearly to the Freeport Series, or top of the Lower Coal Measures. The hard "shells," or crusts of white flint, found at different depths in this, and many other wells, and broken by the auger-bits only with extreme difficulty, are deserving of particular investigation. They seem to form impervious sheets of precipitated silica, effectual barriers against any general movement, upwards or downwards, of the underground drainage. The red clays (kiel) at 347 and 417, are the two "Red Bands of the Barren Measures." The coal at 370 lies between them; and its place is in the hillside at Pittsburg, not far above the mouth of the Manchester Well, last given.

By a combination of these four records, therefore, we have a complete section of strata extending from the Great Pittsburg Coal-bed down through the Barren Measures, Lower Coal Measures, Great Conglomerate, No. XI or Lowest Coal Measures, Sub-carboniferous Limestone, No. X sandstone, No. IX red shale, and the Devonian shales and soft oil-bearing sandstones of No. VIII.

A letter announcing the death of Prof. C. C. Rafn, at Copenhagen, October 20, 1864, was received from Mde. Rafn, dated November 30, 1864.

Donations for the Library were received from the Imperial Academy and Geological Institute, at Vienna; the Horticultural Society, at Berlin; the Royal Academy, and Royal Observatory, at Bruxelles; the London Geological and British Meteorological Society, Trübner & Co., Massachusetts Historical Society, Harvard College, Dartmouth College, New Bedford Public Library, New Jersey Historical Society, Historical Society of Pennsylvania, Franklin Institute, C. H. Hart, Pennsylvania State Library, at Harrisburg; Girard College, Eastern Penitentiary, Blanchard & Lea, Dr. Wood, and Mr. Lapham of Milwaukie.

A copy of Transactions, Vol. XIII, part 1, was laid on the table.

The death of several members, never reported to the Society, was communicated in a letter to the Librarian from Dr. Asa Gray, of Cambridge, viz.,

Edwin James, of Albany, died about 1863.

John Davis, of Boston.

Dr. D. F. Eschricht, of Copenhagen, in 1863, or 1864.

Mr. Chase communicated a short vocabulary of well-established Copto-Egyptian words, to be used conveniently by scholars. This Vocabulary is compiled almost exclusively from Bunsen's "Egypt's Place in Universal History."

Abode, aa; aft; ha.
Abominable, bt; btn-nu; btf.
Above, hr; hri; χaa.
Abydos. Abut.
Abyss of waters, un nu.
Accompany, bs; stku?
Acquaint, rχ; han; hno.
Acre, ar.
Addle, st.
Address, *n.* as.
Adhere, tka.
Adherer, the, taki.
Adjust, hp; χχ.
Adore, bχ; han; hk-nu; sb; sns.
Adorn, fakr? an.
Afflict, χm.
Agree, maht.
Air, nif.
Alauda Calandra, bhu.
Alive, anχ; aneχ.
All, nb.
Also, au; ha; ki.
Altar, χa; χaui; χau; χaiu.
Always, nhh.
Amber? s-χbt; χsbt.
Ammon. Amn.

Anas leucocephala, bs-bs.
Anath. Anaitis. Anta.
Anchor, to. χsf.
And, v. Also.
Anger, kant.
Angle, kan.
Anklets, ar; mn-nfr.
Annihilate, aχm; χm.
Anointed, hrhu.
Another, ki.
Answer, ufb. [χs; χtran.
Antelope, ar; al; mat-ht; nuhu;
Ape, aani; ani; kaf.
Appear, har; hn; hr; ptr; 'un.
Appearance, an; an-nu.
Applaud, hs.
Appoint, tχ.
Approach, amn; ar; as; shr; u;
Approved, stp. [χnt.
Apron, basu; ſnti.
Archer, maχ; mχa.
Ardea Nycticorax, ruχau.
Arm, *n.* aa.
Arm, fore, mn; mnmn.
Arrange, ſm.
Arrive, mna.
Arrow, sr, st.
Arrows, bundle of, χrſ.
Arura, v. Acre.
As, m.
Asp, mhn.
Ass, iu; naa; st.
Assemble, s-sah.
Assembly, saah.
Assistant priestess, ah-i.
At, χr.
Attack, rutn.
Authority, snb.
Avenge, nt.
Avoid, tm.
Axe, akah.

Back, *n.* pst.
Back, to look, annu.
Bad, bt.
Bag, arf; mru.
Balance, *n.* maχa; *v.* χχ.
Balsam? baka.
Barge of Socharis, hni. See Boat.
Barley, bt; nap; napr; su; χn.
Base, v. Bad. Abominable.
Basilisk, ara; hara.
Bat, st-aχmu; takai.
Battle-axe, aka; χtn-i.
Be, ar; au; pu; r; tr; un.
Bean, auru.
Bear, atp; fa; kr; pa-pa; ta; tam;
Bear off, s-χp. [χn; nun.
Beard, mrs.
Beast, bs.
Beast of chase, ba-su.
Beat (strike), χi-χi.
Beauty, an; an-nu.
Bee, ht.
Beg, ks.
Beget, ms.
Begin, -ning, ha.
Behind, ns; nsu; sba.
Being, un. See Be.
Below, kar.
Bend, kan; kna; sna.
Beneath. See Below.
Beseech, rtb; ks.
Besides, haru.
Between, uta.
Bier, aa.
Bier, to deposit on, s-tr.
Bind, arf; hak; hmsa; mr; sak;
Bird, hp. [s-ka; snh; sn-n; ark.
Bitumen, sf-t.
Black, kam; nhsi.
Bless, amaχ.
Blood, snf.

Blow, to, nif.
Blue, χsbt.
Boar, χaau; ſau; rru.
Boat, tpt; ua; ba; ta; mna.
Boats of burden, usχ.
Boat, to go by, ta.
Boat, to tow, mna.
Body, a. χa.
Boiling, ubt.
Bolt, to, s-χ; ſm; kar.
Bombicillo, suru.
Book, ſa.
Born of, af; au; ms; χaa. Prof. Lesley has noted the Japanese analogues, musuko, *son*, mus-may, *daughter*. Cfr. Y. ako, *male*.
Born of, to be, aa.
Bow, *v.* bka; rs.
Bow the forehead, thni.
Bow, *n.* pt.
Bow-legged, tn-rat.
Bow-case, krχ.
Box, *n.* han; tb; χn-nu.
Boy, aat.
Bracelet, mn-nfr; ar-t.
Brass, χnm.
Brazier, rkh.
Bread, ſa; ak; at; hpt.
Break, skar; tnru.
Breast, kan; χn; s-χm.
Breast, female, mnt.
Breast-plate, utau.
Breath, fn-ti; nif. See Blow.
Breath, to give, sns; srk; slk.
Breathe, srk; ssm; s-sr; ss.
Brick, tb.
Brilliancy, ui (D.wi).
Brilliant, to be, nn.
Bring, bs; nun.
Bring forth. See Produce.
Bristle (of eyebrow), an.
Broad, usχ.
Brother, sna.
Bruise, tr; χm.
Buckle, mht.
Build, at; atn; kat; se-menχ.
Bull, ka; tpak?
Bulwark, nχm.
Bundle of arrows, χrſ.
Burn, rkh; tau.
Bushel, ſa.
Butt, to, ab.
By, am; an; m; r.
Cabin, maat; sk; sbkt; iti.
Cackle, kaka; nkaka.
Cake, snt; tp; tpt; χa.
Calasiris, kraχr.
Calf, ab; hu; mas.
Call by name, rnnu.
Camel, kamr.
Camelopard, sr.
Cap, χnr.
Cap, to, bn-bn.
Capsize, s-χt.
Capture, kf; kfa; pnka; sfχ.
Carpenter, to work as, akk; kk.
Carry, fa; ta; tam.
Carve, bak.
Case, χr.
Casque, χnr.
Cat, χai; χau; tsm?
Cattle, mn mn.
Cave, cavern, hu, tph.
Ceiling, hai.
Cell, r.
Centipede, rrk.
Ceremony, bχ; uχ.
Chair, hrs; kani.
Chamber, as.
Chaplet. See Crown.
Chapter, r.

Charadrius armatus, tut.
Chariot, markabuta; 'urri; hrri.
Chase. See Capture; Beast.
Chastise, af; ufa.
Cheat, *n.* χab.
Cheese? sr.
Chest, tba; tn-nu; χm; kara.
Chew, kaka; snm.
Chief, asi; ata-i; ha; sr; ti; χaa.
Child, rr; χart; χn; χr; frau.
Chimæra, ba; sak.
Chisel, to, bak; rk; srta.
Circuit, mr.
Clasp? an-ka.
Claw, aka.
Clay, ha.
Clear, χsr.
Clip, tha.
Clod, a-t.
Clothe, hbs; χbs.
Club. See Mace.
Coffin, kara; karas.
Coitus, sta.
Colchicum, mnh.
Collar, habnir; mna; mχt; usχ;
Collect, u; s-ka; sha. [χbu.
Come, ai; a; i; i-u; maau; mai;
ma-u; mna; sua; u.
Command, han; han-han; han-nu;
Conceal, amn; hap. [tu.
Conceived, aai.
Conclusion, ark.
Condemned, nsai.
Conduct, to, tn; tn-nu; mas; ms;
Confine, fta. [sta; stkn; χn-nu.
Conquer, nrau; neχt; nχt.
Consecrate, χrp.
Consecration, utn.
Consent, χtr.
Constellation, sah.
Construct, kat.
Contend, kar; kl.
Cook, ps.
Copper, mfk; mfka.
Coracias Graculus, an-heb; kannu.
Cords, nuh. See Collar.
Corn, bt; bt-i; npa; npra; su.
Corn, ear of, χms.
Corn, to stack, usb.
Cornelian, an-m-hat ("stone of
Cornice? ap-i. [heart").
Couch. See Seat.
Counsellor, sab.
Counterpoise of a collar, manχ.
Cousin, rχ.
Cow, ah; aua; ha; ka; kau.
Crafty, sab.
Crane, au; ta; utau. See Heron.
Create, atn; hm; kam; sapi.
Crime? χta.
Crocodile, msuh; sbk.
Crook, *n.* au.
Crowd, s-ka; sha.
Crown, 'urr; 'ur; atf.
Crown of flowers, mah; mh.
Crown, game of, mhu.
Cry out, aχ.
Cubit, mah.
Curl, sn-nu.
Curse, ns.
Cursorius Isabellinus, sth.
Cut, bhn; hska; ki; sf-t; skar; sχ;
Cut the throat, sf. [tsnu; fat.
Cynocephalus. See Ape.
Dagger, ba-su; bs-u; χaa.
Dance, aba; ks-ks; mk; trf;
Dandle, rnn; rr. [abχ; λb.
Darkness, aχχ; akk; kk; uχau;
Dates, bs; bun; nbs. [krh.
Date palm, baka; bs; nbs; bnr.
Dawn; Day, ha; har; ra; rhu;
Dead body, χat. [at; ht.

Deceit, χb.
Deceive, kar.
Deck, nχm.
Declare, rχ.
Decorate, bak.
Deer, hann; kau.
Defending, usr.
Deflect, kna.
Delight, kam; rf.
Deliver, χnp.
Demon, good, hu-t.
Denuded, bχta.
Deplore, nhp.
Deposite on bier, s-tr.
Deprecate, snsn.
Desolate, to, χft.
Despatch, aspu.
Detain, pnti; snti.
Devastate, sfχ.
Devil, χft.
Devote, amaχ.
Devour, snm.
Devourer, am-t.
Diadem, χa.
Die, mu; mau.
Direct, nm; χu.
Disc of sun, a-tn.
Disperse, χanru; χsr.
Dispose, sr.
Distance, ua.
Distinguish, tma; ts.
Distribute, sr.
Disturb, tχ.
Divide, uta; a-ka.
Divine head-dress, atf.
Division, pχr.
Do, iri.
Dog, uhar.
Door, ra; ru; sb.
Doorpeg, apt.
Drag, sa.
Dragon, app.
Draw water? mhi.
Dream? rχ.
Drink, bah; hka; sa; sau; sr; shr.
Drip, tf-tf.
Drunk, tha.
Duck, apt; bs-bs; ha; hp; kambt; r; s; sr; st; trp; χpt.
Duckling, hn-nu; un.
Duration, ha.
Durite stone, mn.
Eagle, aχm.
Ear, mstr; at.
Ear of grain, nχm? χms.
Earth, ta; tar.
East, abt; ibt.
Easy, to render, matn.
Eat, am; kaka; ust; uχa.
Ebony, habn; hbn.
Egg, suh.
Egypt; "Labyrinth-land," mr; mr-tar.
Egypt, Lower, hb.
Eight, ss; fmen.
Elbow, sna; kanaa.
Elder, 'ur.
Electrum? s-χbt χsbt.
Elephant? abu.
Elevate, tn-nu.
Embalm, kr; tr.
Embalmment, karas; kas.
Emerald? ssm.
Enamel. See Electrum.
Encase, s'ha.
Enclose, snnu.
End, ark; asf; iuspu.
Enemy, χmi.
Engrave, rut.
Enter, bs.
Entrails, kans; kns.
Entrance, χnt.
Entreat, ks; nini.

Envelope, namn.
Erect, nhas.
Escape, tm.
Escort, ms; t.
Establish, tt; s-mn.
Eternal, tta.
Evening, rhi.
Evil, ban; hu; χas.
Exalted, tts.
Examine, uts.
Excite, nhas.
Exist, χaa; χpr.
Extend, pχt; pχ; pt; st; snt-nt.
Extinguish, aχm.
Extremities, ba-ba, ab-ab.
Eye, iri.
Eye of sun, symbolical, utau.
Eyebrow, an-hu.
Eyebrow, bristle of, an.
Fabricate, ntr. See Make.
Face, hri.
Facilitate, matn.
Fall, χatb; χr.
Fan, χaibt.
Fashion. See Shape.
Father, atf; fat; tf.
Fault, asf.
Fear, hati; hrs.
Feed, uah.
Feldspar, green, nχm.
Festival, hb; χa.
Field, ah; ah-a; ha.
Fight, kar.
Fill, mah; mh.
Fillet, hk.
Filthy, hu; hs.
Finch, an-nbu; sabu; sχa.
Finger, tb.
Fire, sr.
First, χrp; ſa; api.
Fish, to, ham; hm; sn-nu.
Fist, kp; χfa; χp.
Five, tu.
Flabellum, sr.
Flame, bs; nsr; ss-i; st; χt.
Flax, hma; ma; snti; χnti; χms.
Flesh, ab; af.
Flogged, to be, ama.
Floor, kaa.
Flour, tka.
Flow, baba; hbb.
Flower, hrr; rnpa. See Crown.
Flute, mm; sab; sb; sba.
Flute player, sba.
Fly, a, af.
Fly-flap, smi; sr.
Fly, to, ap; aχm; fai; pa; pai.
Foam, hbt.
Fodder, sm; χrſ.
Fold, kab.
Food, hrr; at; hpt; χa.
Foot, pti; pts; rt.
For, an; n; r.
Force, nm; nχt.
Fore-arm, mn.
Forehead, thni.
Foreigner, mu.
Foreseeing, phti.
Form, to, atn; mnχ; sapi.
Fornicate, nk.
Fort, bχn; tχa; χtm.
Fortnight, tna.
Found, to, snt.
Fountain, hnbi.
Four, aft; ftu.
Fowls, apt.
Fraction, r.
Fragrance, tf.
Frighten, s-hr.
Frog, hk.
From, am; an.
Frontier, mr; taχ.

Full, to, rχ.
Fuller, rχ.
Funeral chest, kara.
Furnace, karr; kll.
Future (particle of), au.
Game of the crown, mhu.
Gap, pχa.
Garden, rhi.
Garland, mah.
Gate, sb; sbχ-t.
Gather, sm.
Gazelle, aa; ar; htu; kahs; sta.
Geese, apt.
Gem, am.
Germinate, rut.
Giant, ap-p.
Gild, nbi.
Giraffe, srr.
Girdle, 'unχ; hnχ.
Give, ta.
Give breath to, sns; sns-hu.
Glass, ſbn.
Gleam, mau; pst.
Glorify, aui; suaχ; sbaau.
Glory, aaiu; aau.
Glow, haha; 'ut.
Go, aka; hr; ta.
Goat, ba.
Go back, χsf.
Go before, ha.
Go by boat, ta.
Go down, pna.
Go out; har; hm; uta; uts.
Goading, s-χb.
Goat, abu; ba; ka; htu.
God, hakhak.
God, goddess, ntr.
Gold, nb; nm.
Good, nfr.
Good demon, hu-t.
Goose, smn; sr; apt.
Gore, tχr.
Govern, hm.
Grain, npa; npra; uχm.
Granary, sn-ut.
Granite, mat-ht.
Grapes, arr.
Grasshopper, hm.
Grease (leather), to, ths.
Great, naa.
Green basalt, bχn.
Green feldspar, nχm.
Green color? tuaut; ut.
Grind, tr; nt; nk.
Groan, akb.
Grow, tar.
Gryphon, aχχ; sfr.
Guard, ari.
Guard cattle, maan.
Guess, tp.
Gullet, χbb; χχ; bb.
Gum wood, kam.
Hades, amn-t.
Hail! ha.
Hair, sn; tam-ua. Lock of hair, nχt.
Half, tna; m; meti.
Hall, arr; nu; usχ.
Hallow, amaχ.
Halyards, nfri.
Hammon. See Ammon.
Hand, tt. See Fist.
Hang, rs.
Hare, aχa-tr; s-χat.
Harp, bn.
Harrow, hr.
Hatches of a boat, maat.
Hatchet, akah.
Hate, mas; mst.
Have, kr.
Hawk, aχm.
He, f; su.
He-goat, ka.

Head, ap; ap-i; ha.
Head-dress, divine, atf.
Head-rest. See Pillow.
Hear, stm; s-at.
Heart, har; ha-t; ht.
Heart-stone. See Cornelian.
Heat, rkh.
Heaven, pe.
Helmet, χprf.
Hemp. See Flax.
Her, s.
Heron, hnt; kapu; ruχan; snsn.
Hide, a, an-m. [See Crane.
Hide, to, hap.
High, fa.
Hill, hu; tu.
Hippopotamus, apt; tb-t.
Hoe, tf.
Hog, rra.
Hold of a vessel, apt; usχ.
Honey-comb, kabi.
Horizon, pχr; pkar.
Horn, ab; ba.
Horse, htr; htra.
Hour, 'un; 'un-nu; kp; fp; tp.
House, a, baita.
Hull of boat, tpt.
Hunger, hkar.
Hunt, kf; kfa; χns.
Hurl, sabχ.
Husband, ha; ka.
Hyena, bhui.
Hypocrisy, χau.
Hypocrite, χab.
I, a; u; nuk.
Ibis, hab; hb.
Idle, knau; s-sat; ba; sbaat; sk.
Idleness, asf.
Illuminate, ubn.
Illumined, uχ; bχ.
Image, χrp.
Imagine, χmhu.
Impious? asb; sba.
Impudent, rka.
Impure garments, sfχ.
In, am; m; r.
Incense, sntr.
Incline, bhn; bka; rk.
Increase, tr.
Ingot, utn.
Iniquity, χbt.
Insect, rfrf.
Intellect, mau.
Inundate? bah.
Invert, aχ; pna; sχ-t.
Invoke, ufa.
Iron? ba.
Is, ar; r.
Island, mr.
It, s; su.
Ivory, ab.
Jackal, sab; absi.
Jasper, kam; ks; kspu.
Jet of flame, bs.
Join, hpt. To join cords, tka-r.
Joy, ha.
Judge, to, hp; stm; stp.
King, sun-t; sutn.
King, sanctity of, hntr.
Kiss, mr.
Knead, nk; nt.
Knee, kan-rat; sna. See Bend.
Knit, aa.
Kukufa sceptre, tam.
Kuphi, tf.
Labyrinth, mr.
Lady, hm; hma.
Lament, aakb; akb.
Land, st.
Large, usχ.
Lark, ama; bhu.
Latchet of sandal, th.

Lay out, smn; sbak.
Lead, *n.* th th; thti.
Lead along, ts.
Leaf, χr.
Leap, sp.
Length, ua; χau.
Libation, htb; kabh; utn-nu.
Lie in (with child), papa.
Life, anχ.
Light, bka; bχ; hai; hi; ht; mau; nu-nu; pſ; ubn; ui; un; 'ut.
Light, to give, s-ht.
Lighten, pſ; snk.
Like, χa.
Likewise, ki.
Limb, ha.
Linen. See Flax.
Lintel, ati.
Lion, maau; maui; rabu; labu.
Lioness, pχa.
Lips, spt.
Liquids, hka.
Listen, at.
Little? nts.
Live, Living, anχ; aneχ.
Lo! as.
Load, atp.
Loaf, snnu.
Lock of hair, nχt.
Locust, hm.
Loins, at.
Long, ua; χu. See When.
Look back, annu.
Lord, nb; tts.
Lotus, sſin.
Love, mr.
Lower Egypt, hb; χb.
Lynx, maft. t.
Mace, ht; sχu.
Magus, sab.
Make, iri; kaut; kam; kat; nmχ; ntr; sχa; s-χar; tr; χa; (nhp, *to make* as a potter).
Male, ka.
Man, ruma.
Manifest, har.
Manifold, meh.
Mankind, pa; rt.
Mansion, ra.
Many, hh; χa; hka.
Mare, ssm.
Marsh, ah.
May, ma.
Me, a; u; nuk.
Measure, a, han; hpt; mn; tb-h.
Measure, to, χa.
Meek, 'urt.
Men, rt.
Metal armlet, mska.
Milk, art.
Mill (to beat), nt; χi-χi.
Minister, a, sm-s; sm-sm.
Mirror, ma-u; ma-hr; hu-hr.
Moisten, harp.
Molest, sk.
Monkey. See Ape.
Monoceros, ramaχ.
Monument, mn.
Moon, aah.
Mother, mu.
Mould, to, sapi; nhp.
Mount, ap; ap-a; ap-p.
Mourner, hb.
Mouth, r; ru.
Move, kaa; ak; tnnu.
Mow, asχ; usχ; χabu.
Mullet, bari.
Mummy, karas.
Nails, suh.
Naked, to be, haa.
Name, rn.
Namely, ks.

Nation, hs-mn.
Navigate, χt.
Neck, nhb. See Nuque.
Negro, nhsi.
Nest, s-ſ.
Net, s-χt; χt; ſna.
Night, afru; kar-hu; uſa; ſr.
Nine, psit.
No, am; un; tm; χm; en; nen.
Noble, aa; as; atai; sr.
Noose, s-fχ.
North, Northwind, mah.
Nose, fnt.
Nosegay? ab; ih.
Nostril, ſra.
Not. See No.
Nourish, snkaus; snχn.
Numerous. See Many.
Numidian goat, abu.
Nuque of neck, mati.
Nurse, mna; sunχ; χnm.
Nurse's collar, mna.
Nursling, rru.
Nyeticorax, bn; ruχau.
Oar, usr.
Oarblade, hpi; hpt.
Oarlock, bas-t.
Obelisk, tχn.
Oblique flute, mm.
Obscurity, kk. See Darkness.
Ocean, iuma; ht-hr.
Odor, st.
Of, an; m; n; r.
Offer, hpt; ka; χrp; ta.
Oh! a; ha.
Oil, tat; tt.
Olive. See Oil.
Omit, sbaat.
One, ua; uot. In Coptic, un, *to be*, is used.
One of a class, rpa.
Open, 'un; sχ; hn; sn.
Oppress, ht.
Optative particle, ma; mai.
Orbit, kar; sn-n. See Bind.
Order, to, sr; tχ-tχ.
Order, in, rta.
Orichalcum, kaχa.
Other, χt.
Other things, aχt.
Overtake, sfχ.
Overthrow, sfχ; s-χr; s-χt.
Ox, kau; sab.
Packet. See Bag.
Paddle blade, χrp.
Paint, sχa.
Palanquin, uts.
Palm, date, baka; bnr; bs; nbs.
Palm-wine, baka.
Palm of hand, kp. See Fist.
Panegyry, hakr; hb.
Papyrus, tt.
Part, r.
Pass, sn.
Path, hr; matn nu; tr?
Peaceful, to be, har; hrt.
Pearl, am; an-m.
Pectoral plate, utau.
Peg of a door, apt.
Pendant, utau.
Perfume, tf.
Peritius, prtis.
Persea, the, aſt.
Person, a, s; pai.
Picture, χr.
Pigmy, nmm.
Pile (a game), ar.
Pillow, 'urs; huls.
Pint, hpt.
Pitch, sf-t.
Placable, 'urt.
Place, to, ama; mn; rta; sr; tum;
Place, a, aa; hm; ma; nu; ſta.

Plank, pχa.
Plantation, rhi.
Play the harp, s-ka.
Play at latrunculi, aasb.
Please, ran.
Pleasure, rf.
Plough, hab; hb; s-ka; χb; χba.
Pluck corn, h[u].
Polish, snaa.
Pollute, tu; tu-tu.
Pool, barkabuta; ht; htb; f.
Porcelain, fbt.
Porphyrio hyacinthinus, shh.
Potter's stand, nhp.
Pottery, χatab; manχ?
Pouch, arf.
Pound grain, s-hm.
Pour out, htb; 'utb; uah.
Power, tam; χfa; fin.
Powerful, to be, nχt.
Præformant of future, au.
Præformant of optative, ma; mai.
Prætorium, tb.
Praise, sbaau.
Pray to, heu.
Prayer, as; tb-h; tb-ti.
Precede, ha.
Precinct, an.
Preference, Preferred, sm-s.
Prepare, smn.
Prepuce, karnata.
Present, ht.
Pride, tu-tu.
Priest, hnt; stm; uab; ab.
Priestess, sua. Assistant priestess, [ah-i.
Principal, as; χrp.
Prison, ra; fta.
Prisoner, tnhu.
Prisoner, to take, kf; kfa.
Privilege, kar; kl.
Proclaim, ka; af.
Prostrate, bka-bka; tb-tb.
Pudendum, baah; karnata; ms.
Pure, Purify, ab; rχ; uab; uχ.
Purse, arf.
Put to flight, pt-pt.
Pyramid, br-br.
Quiet, to be. See Prostrate.
Quit, hm.
Race, human, rt.
Rage, kant.
Raise up, af; nhas.
Ram, ff; fft.
Rat, pn; pn-nu.
Ravish, nm.
Ray, st.
Ray fish, rm.
Reap, asχ.
Receive, ka; ra; tp.
Reconnoitre, hat-hat.
Recurvirostra Avocetta, tm.
Red, Red crown, tfr.
Red jasper, χnm.
Redoubled, kabi.
Reeds, aak.
Reel, tha.
Refresh, kab.
Refreshments, hka.
Reign, χu.
Rejoice, ahaha; ha; ka; sχχm.
Relative, a, rχ; kan.
Renew, rnpa; rut.
Reprobate, χft.
Reptile, ttfi.
Resemble, χa.
Reservoir, f.
Resplendent, to be, bn-bn.
Resting-place, as.
Restrict, χnark.
Revolt, tn-tn.
Revolter, nhsi.
Rhinoceros, ab.

Produce. See Beget.
Prop, sba.
Ribs, apt; sph.
Rigging, a-tu-kar.
Rise up, ap; ap-a; ap-p; ar; aχm;
River, aru. [thun; tn-nu.
Road, hr; matn-nu.
Roar, ham-ham.
Roast, haha.
Rob, kar.
Rock, st.
Roll, a, s-χa.
Rope, as; mn-nu; nuh.
Rub, tr.
Rudder, hm; hua; hms.
Ruin, sfχ.
Rule, hka; mak; χu.
Ruler, hk; hka.
Run through, ſas.
Sacred cakes, sn-nu.
Sacrifice, ta.
Sail, tpak; tkai.
Sail to, ta.
Saloon, usχ.
Salt? mrh.
Sanctify, hnt; hntr.
Sandals, tb-ti.
Sandstone, rt; rut.
Sarcophagus, kara; tba.
Saturn, sb.
Save, nhm.
Saw, to, us.
Scale (balance), maχa.
Scarabeus, χpr.
Scarify, tma.
Scent, sna; srk; ssm.
Sceptre, kind of? ksm. See Ku-
Scimetar, χpχ. [kufa.
Scolopax, bnka.
Scorpion, srk; slk.
Scrape, s-ka.
Scribe, sχai.
Sculpture, rt; s-rka.
Sea, ht; iuma.
Seat, kat; hs.
Secret, kr.
Section, s-χr; χr.
See, ma-u; maa.
Seed, ka; rt.
Seek? χnm.
Select, stp.
Self, ha; ts.
Send, tn-nu; χn-nu.
Separate, tma.
Sepulchre, bu.
Serve? ais.
Sesamum? ssm.
Set over, rpa.
Set up, ha; ka; smn.
Seth, st.
Seven, sfχ.
Sew, sta; sat.
Shades, aχχ.
Shaft of column, pt.
Shape, sapi; χpr; ſft.
Shave, χak.
She, s.
Sheep, sr. See Ram.
Shepherd, mna; ſasu.
Shield, akam.
Shin, mn.
Shine, nn; pst; ʻun; ubn.
Shirt, snti.
Shoe-latchet, ths.
Shoot, tr; pt; pχt.
Shoulder, kahu.
Show, ptr.
Shrine, s-ſm; kara.
Shut, s-χm; s-ſ; χt; χtm; ſt.
Shuttle, nt.
Side, bat; sa; spir.
Signet, tb-h; mna-t.

Silver, ht.
Sin, ban; hu; ſta?
Sindon, snti.
Sing, hs.
Sister, sna.
Sistrum, sχχ.
Sit down, bka-bka; hms.
Six, sou.
Skein, sta.
Skin, an-m; bs.
Slain, the, htb.
Slaughter, tuaua.
Sleep, χnm.
Slice, aſr; tsnu; ſba.
Sling, ts.
Smash. See Break.
Smell, χnm; sti.
Smite, sma; χpχ; χr; ſr.
Smith, kara.
Snake, hf; rra; ru.
Soar. See Rise up.
Sofa. See Throne.
Soldier, kraſr; mata; mnf; mni.
Son, iri; s; sba.
Soothe, skar.
Soul, ba.
South, sua; sur.
Sow. See Seed, Boar.
Spark, tka.
Sparrow Hawk, bak.
Speak, rχ; tt; tu.
Sphinx, akr.
Spike, sr.
Spin, sta.
Spirit, pure, rχ.
Splendor, auu; mau; bχ; uχ.
Sport, abu.
Spotted, ab.
Sprinkle, pnka.
Spy, hap.
Stable, ah-a.
Stack corn, usb.
Stagger, tha.
Staircase, arr.
Stalk (of corn)? mſa.
Stalk along, aka.
Stand erect, aha.
Stand for vases, s-haa.
Star, sb; χab.
Starve, hkar; χbni.
Statue, tut.
Stay, hm.
Stead, hbt; snti.
Stench, sti.
Step, ar.
Stern of vessel, hptu; utu.
Stibium, smt.
Stick, a, sχu.
Stockade, bχn.
Stone, an; bn-nu? st.
Stop, ſsf; fn-ti.
Storehouse, ra.
Strangle, hmsa; s-hm.
Strap, mss; ʻunχ.
Straw, tha.
Stream, ba-ba; hbb.
Strengthen, amaχ.
Stretch, uha; ps.
Strike, h[u]; hu.
Strong, nχt; seneba.
Struck, ſr.
Stupefy, tmat.
Subdue, sbk; sma; tma; tb; χtb.
Substance, ha? maai; au.
Suckle, rr.
Sue, snsn.
Suffocate, akt.
Sun, ra.
Sun, disk of, a-tn.
Sun, symbolical eye of, utau.
Sunbeams, ama? st.
Sunset, kar.

Sun's orbit, snnu.
Supplicate, han-nu.
Supply, srk; slk.
Support, nt; nk.
Suspend, aχ; rs; ts.
Sustain, uts.
Swallow, a, mn.
Swan, apt.
Swill, bah.
Swim, nb.
Sword, sf.
Sycamore, nh; nhai.
Table, thu.
Tablet, ht.
Take, nm; ſp.
Take prisoner, kf; kfa.
Tamarisk, asr.
Tame. See Subdue.
Tank, ſ.
Taste, tp; tpp.
Ten, met; ment; mnt.
Terrify, hat; hr.
Testes, karu.
That is to say, ks.
The, nai; p; pa; pu; pui; ta.
Thebes, apt; ta-ap.
Then, as.
They, sn.
Thigh, χpt; χpχ.
Thing, bu.
Thirst, ab; abu.
This, pa.
Thou, k; nk; t.
Thread, ball of, sta.
Three, ſamet; ſament; ſomt.
Throat, part of, kaf.
Throne, kat; hs.
Through, am; m.
Time, tar; tr; sp; sb.
Time, some period of, ast.
Time (as once, twice), χp.
Tin? s-χbt; χsbt.
Tips, ba-ba; ab-ab.
Tip, to, bn-bn.
To, ar; n; r; χr.
Together with, hna; hr.
Tomb, ſta.
Tooth, abh.
Tortoise, apχ.
Touch, kah.
Tow, to, mna; sta.
Towline, ha-ti.
Towards, an; ar; r; ſr.
Tower, mak; makataru.
Trample, pt-pt.
Transfix, tr.
Transform? ſb-ſb.
Transport, to, tm; ts.
Transport (vessel), hua.
Traverse, sm; sn; ſas.
Tread on, χnt.
Treat with, maht.
Tremble, stut.
Tried (select), stp.
True, Truth, ma.
Truss of hay, χrſ.
Try, uts.
Tumble, χbt; χtb.
Tunic, sχnt; ſnti. See Shirt.
Turn away, sna.
Turn back, ſsf; hm.
Turtle dove, mn.
Tutor, χmns.
Twine, to, mna.
Twist, tka-r.
Two, snau.
Type, ar; ka; χpr.
Typhon, st.
Under, ka; kar; χr.
Undertaker, hb.
Unicorn, ramaχ.
Unite, hpt.

Up, to rise, ap; ar.
Upon, hr; api.
Uræus, ara; hara.
Ursa Major, χpχ.
Utensils, menχ.
Valley, an.
Vanquish, nrau.
Vase, han; mn; tb.
Vessel's hold, apt.
Vestibule, χn.
Vex, hs.
Viand, ab.
Victorious, akar.
Victory, kan; kan-nu; nsr; ssr.
Vigilant, ph-ti.
Vine, arp; arr.
Violate, χb.
Violence, to use, nm.
Vulture, nrau.
Walk, ſm.
Wall, mr? sb.
War chariot, 'urri.
Warlike, akar.
Warp a boat, mna.
Wash, aa; rχ; iua.
Wash gold, nkbt.
Wasp, χb.
Waste, to lay. See Devastate.
Watch-tower, mak; makataru.
Watchful, ph-ti.
Water, mah; muau; nm.
Water for washing, aa. Abyss of
Wax, mrh. [waters, mnnu.
Weep, Weeping, nhp; rm.
Weight, tb-h; tχ.
Wells, utbu.
Wet-nurse, mna.
Wheat. See Corn.
When, rta; ſin.
Whetstone, an.
Whilst, m[n]χ-t; tr.
Whip, χχ.
White, abſ; ht.
Wicked, bχta? nſni? sb; sba
Wife, hm; hma.
Wind, nif.
Windpipe, ah-i.
Wine, arp.
Wing, mah; tuh.
Winged disk, χpi.
With, am; hna; hr; kar; m; n; χr.
Witness, ma-t-ra.
Wolf, hunſa.
Wood, ba; ſa.
Wood, a kind of, apt.
Wool, an-m.
Work, bak; tr.
Work as a carpenter, kk; akk.
World, ta.
Worm, fnt; rf-rf.
Worship, tua; hati.
Woven things, sχta.
Wrapper, tba.
Wretched.
Write, sχai.
Yellow; Yellow jasper, ant; anti.
Yellow paint, pst.
Yesterday, sf.
Young, hn-nu; rupa; 'un-nu.
Youth, rnpa; rpa.
Youthful, χr.

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a, I; me; a house; oh!
aa, to knit; to wring out; to be born of; to wash; water for washing; an arm; a gazelle; a noble; place; abode; noble; bier.
aah, moon.
aai, conceived.
aaiu, glory.
aak, reeds.

aakb, to lament.
aani, ape.
aasb, play at latrunculi.
aat, a boy.
aau, glory.
ab, flesh; viand; thirst; a nosegay; to butt; a horn; ivory; rhinoceros; calf; pure; to purify; spotted.
aba, to dance.
ab-ab, to butt; horns; extremities.
abh, a tooth.
absi, jackal.
abt, the East; a month.
abu, a Numidian goat; an elephant; thirst; to sport.
abut, Abydos.
abχ, to dance.
abſ, white.
af, flesh; born of; a fly; to chastise.
aft, an abode; four.
ah, a cow; field; marsh.
aha, to stand erect; field; a stable.
ahaha, to rejoice.
ah-i, assistant priestess; windpipe.
ai, to come.
ais? to serve.
ak, bread; to move, go.
aka, a claw; to go, stalk along; to divide; battle-axe.
akah, a hatchet.
akam, a shield.
akar, warlike; victorious.
akb, to groan; lament.
akr, sphinx.
akt, to suffocate.
al, antelope.
am, in, with, by, through, from; no, not; to eat; gem, pearl; a beam.
amȧ, a lark; sunbeams; to eat; to place; to be flogged.
amaχ, to devote, strengthen, bless? hallow.
amn, to conceal; to approach; Ammon; to envelope.
am-naa, some mineral?
amn-t, Hades.
am-t, devourer.
an, stone; whetstone; bristle (of eyebrow); beauty; appearance; of, from, by, for, towards; to adorn; valley; precinct.
aneχ. See anχ.
anheb, like an ibis; the Coracias Graculus.
an-hu, eyebrow.
ani, ape; cynocephalus.
an-ka, to clasp?
an-m, a pearl; a hide; wool.
an-m-hat, "stone of heart;" cornelian.
an-nbu, a kind of finch.
an-nu, beauty; appearance; to look back.
ant, yellow; yellow jasper.
anta, Anath; Anaitis.
an-ti, yellow jasper.
anχ, life, alive; to live.
ap, the head; to rise up, fly on high.
ap-a, to rise up.
ape, api, head; cornice? first; upon.
ap-p, to mount on high; giant; dragon.
apt, duck; hold of vessel; peg of door; a kind of wood; Thebes; swan; rib; hippopotamus; geese; fowls.
apχ, tortoise.
ar, to be, there is; to, towards, to approach; to rise up; gazelle; arura, acre; anklets; a step or pile (game); type; antelope.
ara, basilisk, uraeus.
arf, to bind; bag, packet, pouch, purse.
ark, conclusion, end; a binding.
ari, to guard.
arp, vine; wine.
arr, grapes; vine; staircase; a hall.
art, milk; bracelet, anklet.

aru, river.
as, to approach; address; prayer; noble, principal; rope; chamber, resting-place; then; lo!
asb, impious?
asf, idleness; fault; end.
asi, chief, noble.
aspu, to despatch.
asr, a tamarisk.
ast, some period of time.
asχ, to mow, reap.
at, a clod; loins; to build; to listen; bread; ear; a day.
at-ai, chief; noble.
atf, father; divine head-dress; [crown.
ati, lintel.
a-tn, to build, create; the sun's [disc.
atp, to bear, or load.
a-tu-kar, rigging.
au, and, also; born of; to be; a crook; a kind of crane; praeformant of future tense; substance.
aua, cow.
aui, to glorify.
auru, a bean.
auu, splendor.
aχ, to suspend, invert; to cry out.
aχa-tr, hare. [hilate, extinguish.
aχm, eagle, hawk, to soar; to anni-
aχt, other [things].
aχχ, darkness; a gryphon; shades.
af, to proclaim; to raise up.
afr, slice.
afru, night.
aft, the Persea.
ba, wood; iron? soul; goat; kind of chimaera; to be idle; boat, [barge.
baah, pudendum.
ba-ba, to flow, stream; horns; extremities.
bah, to inundate; swill, drink.
baita, a house.
bak, a sparrow-hawk; to chisel, work, carve, decorate.
baka, date palm; palm wine; balban, evil; sin. [sam?
bari, a mullet.
barkabuta, a pool.
bas-t, oarlock.
basu, dagger; beast of chase; apron.
bat, side.
bb, gullet.
bhn, to cut, incline.
bhu, lark, Alauda Calandra.
bhui, hyena.
bka, light; to incline, bow. [trate.
bka-bka, to sit down, be quiet, prosbn, phœnix, nycticorax; harp.
bn-bn, to be resplendent; to cap, [tip.
bnka, a scolopax, bird.
bn-nu, a kind of stone.
bnr, palm-tree.
br-br, pyramid.
bs, beast; hide or skin; date, palm; jet of flame; to accompany, bring; to enter.
bs-bs, duck, Anas leucocephala.
bs-u, dagger.
bt, corn; bad, base, abominable; [barley.
bt-i corn.
btn-nu, abominable.
btf, abominable.
bu, sepulchre; a thing.
bun, dates. [splendor; ceremony.
bχ, light; to adore; illuminated,
bχn, fort, stockade; green basalt.
bχta, wicked? denuded.
en, not.
f, he, him.
fa, to bear or carry.
fai, to fly.
fat, father.

fnt, worm; nose.
fn-ti, breath; to stop.
ftu, four.
h [u], to strike.
ha, cow; duck; husband; head; beginning, chief; to begin, go before; a day, duration; joy, to rejoice; a limb, self; also; field, clay; oh! hail! a substance; an elegant kind of boat? to set up;
haa, to be naked. [abode.
hab, ibis; to plough.
habn, ebony.
habnir? kind of collar.
haha, to roast, glow.
hai, light; a ceiling.
hak, to bind.
hakhak, name of God.
hakr, kind of panegyry.
ham, to fish.
ham-ham, to roar.
han, to adore; to command; box, vase, measure; to acquaint.
hanhan, command.
hann, deer.
han-nu, to command; to supplicate.
hap, to conceal, spy.
har, to manifest, appear, go out; a day; heart; peaceful.
hara, uraeus.
harp, to moisten.
haru, besides.
hat, to terrify.
hat-hat, to reconnoitre.
hati, heart; to fear; to worship;
hat-t, some material. [tow-line.
hau, husband; day.
hb, panegyry, festival; mourner, undertaker; to plough; ibis;
hbb, to flow, stream. [Lower Egypt.
hbn, ebony.
hbs, to clothe.
hbt, to steal; to foam.
hen, to pray to.
hf, a snake.
hh, numerous.
hi, light.
hita, a substance.
hk, frog; fillet.
hka, to rule, ruler; drink, liquids; frog; numerous; refreshments.
hkar, hunger; to starve.
hk-nu, to adore; some material.
hm, a place; lady, wife; to fish; grasshopper; to govern; rudder; to go out, quit; to stay; to create; to turn back; locust.
hma, linen, flax; lady, wife.
hmka, a dark stone or material.
hms, to sit; rudder.
hmsa, to strangle; bind.
hn, to be, appear; to open.
hna, together with.
hnbi, a fountain.
hnhr, mirror.
hni, barge of Socharis.
hnnu, a duckling; young; an hour.
hno, to acquaint.
hnt, priest; sanctity; heron.
hntr, sanctity of a king.
hnχ, strap, girdle.
hp, bird, duck; to judge, adjust.
hpi, oar-blade.
hpt, to join, unite; a measure; to offer; a pint; solid food; oar-blade; bread.
hptu, poop.
hr, together with; upon, above; path, to go; to terrify; to appear; to harrow; day.
hrhu, anointed.
hri, face; above; to fear.
hrr, flower; food.
hrri, quadriga.

hrs, a chair.
hrt, to be peaceful.
hs, to sing, applaud; vex; filthy; throne; sofa; couch.
hska, to cut in pieces.
hs-mn, natron.
ht, heart; a mace; to oppress; white, light, silver; a pool; the sea; a tablet; present; daylight;
htar, horse. [bee.
htb, libation; to pour out; pool;
ht-hr, ocean. [the slain.
htr, htra, a horse.
htu, gazelle; goat. [calf; filthy.
hu, to strike; evil; sin; cave; hill;
hua, a rudder, transport.
huls, hurs, pillow; head-rest.
hunfa, wolf.
hu-t, good demon.
i, to come.
ib, the East.
ibt, east.
ih, some plant; nosegay.
iri, eye; son; to do, to make.
iti, a cabin.
i-u, ass; to come.
iua, to wash.
iuma, the sea, ocean.
iuspu, end.
k, thou, thee.
ka, to offer, receive, set up, proclaim, rejoice; a bull, husband, male, he-goat; seed; under; type.
kaa, floor; to move.
kab, to fold; refresh.
kabh, a libation; refreshments.
kabi, a honeycomb; a fold; rekabsak, some substance. [doubled.
kaf, monkey, ape; a part of throat.
kah, to touch.
kahu, shoulder.
kahs, a kind of gazelle.
kaka, to cackle; to eat, chew.
kam, to delight, create; black; black-haired; jasper; gum wood.
kambt, ka-em-net, a duck.
kamr, camel.
kan, a breast; angle; victory; to [bend; relations.
kan-aa, elbow.
kani, chair.
kan-nu, victory; Coracias Graculus.
kan-rat, knee.
kans, entrails.
kant, anger.
kapu, a kind of heron.
kar, below, beneath, with; to fight; to deceive; an orbit; to rob; privily; a bolt; sunset.
kara, sarcophagus, funeral chest; a smith; shrine.
karas, mummy; coffin; embalmkarhu, night. [ment.
karnata, pudendum; foreskin.
karr, an orbit; a furnace.
karu, testes.
kas, an embalmment. [seat; couch.
kat, to build, construct; throne;
kau, animal of the ox or deer kind.
kaut, to make.
kaχa, orichalcum.
kf, kfa, to hunt, chase, take prisonki, another; likewise; to cut. [er.
kk, akk, to work as a carpenter;
kl. See kar. [darkness.
kll, furnace.
kna, to bend, deflect.
knau, to be idle.
kns. See kans.
kp, fist; palm of the hand; hour.
kr, to bear; have. See kar.
krafr, soldier, calasiris.
krf, a bowcase.

ks, that is to say; to entreat, beg;
ks-ks, a dance. [jasper.
ksm? a kind of sceptre.
kspu, jasper.
labu, lion. [medium.
m, with, through, by, of, in, as; half;
ma, true, truth; flax; place; may, præformant of optative; mother.
maai, substance.
maat, cabin.
maau, lion; to come.
mafk, copper; copper ore.
maft-t, lynx.
mah, cubit; wing; crown of flowers; to fill; water; north; north wind.
mahr, mirror.
maht, to agree, treat with; some liquid in a jar streaming like
mahu, chaplet; crown. [milk.
mai, substance; come; may; præformant of optative.
mak, to rule; a watch tower.
makataru, a tower.
manχ, counterpoise of a collar.
markabuta, a chariot.
mas, a calf; to conduct along; to
mat, granite. [hate.
ma-ta, a soldier.
mat-ht, granite; a kind of antelope.
mati, the nuque of the neck.
matn, to facilitate.
matn-nu, road, path.
ma-t-ra, a witness. [tellect; to die.
mau, to gleam, light, splendor; in-
ma-u, a mirror; to see; to come; præformant of optative.
maui. See maau.
maχ. See mſa.
maχa, scale, balance.
maſ, archer.
meh, manifold.
menχ, utensils.
meti, half; medium.
mſka, copper.
mh, to fill; chaplet, crown.
mhi, to draw water?
mhn, asp.
mht, a buckle.
mhu, game of the crown.
mk, to dance.
mm, the oblique flute.
mn, to place; a monument; a vase; liquid measure; a black durite stone; a swallow; turtle dove; fore-arm; shin.
mna, a nurse, wet nurse, to nurse; nurse's collar; shepherd; to twine rope; to tow a boat; arrive;
mna-t, signet. [barge.
mnf, mni, a soldier.
mnh, species of colchicum; a mine-
mn-mn, cattle. [ral substance.
mn-nfr, bracelet, anklet.
mn-nu, rope.
mnt, a female breast.
mnχ, to form, make, things made.
m[n]χ-t, whilst. [frontier; circuit.
mr, to love, kiss; bind; island;
mra, Egypt. See mr-tar.
mrh, wax, salt?
mrs, a beard.
mr-tar, Egypt; labyrinth-land.
mru, packet.
mruri, kind of bird.
ms, to produce; born; pudendum feminæ; to conduct, escort.
mska, a solid bracelet.
mss, a strap.
mst, to hate.
mstr, ear.
msuh, crocodile.
mu, mother; foreigner; to die.

muau, water.
mχt, a kind of collar.
mſa, an archer; stalk of corn?
n, of, to, for, with.
na, nai, the (plur. demonst. pronoun).
naa, great; ass.
nap, napr, barley.
nb, lord; all; gold; to swim.
nbi, to gild.
nbs, dates; date palm.
ne, nen, not.
nfr, good.
nfri, halyards.
nh, nhai, sycamore.
nhas, to erect; raise up; to excite.
nhb, neck.
nhh, forever.
nhm, to save.
nhp, to weep, deplore; to make or mould (as a potter); potter's stand.
nhsi, negro; revolter.
nif, breath, to blow; air, winds.
nini, to entreat.
nk, thou, thee; to fornicate; to grind, knead, support.
nkaka, to cackle.
nkbt, to wash gold.
nm, to ravish; force; to take, direct; water; gold.
nmm, pigmy.
nn, no, not; to be brilliant.
nn-nu, abyss of waters.
npa, npra, corn, grain.
nrau, vulture; to vanquish.
ns, behind; to curse.
nsa, behind.
nsai, the condemned.
nsr, victory.
nsu, behind.
nt, to avenge, support; to mill; a shuttle; name of a tree. See nk.
ntr, a god, goddess; to make.
nts, little?
nu, hall, place (n, *of;* u, sign of plural).
nuh, rope, cord.
nuhu, kind of antelope.
nuk, I, me.
nun, to bear, bring.
nu-nu, light.
nχm, green feldspar; deck of a boat.
nχt, lock of hair; force, strong; to conquer.
nſm, bulwark, deck.
nſni, wicked?
p, pa, the, this (masculine article).
p[e], heaven.
pa, mankind; to fly.
pai, to fly; person.
pa-pa, to give birth to; to bear.
ph-ti, vigilant, foreseeing.
pkar, horizon.
pn, a rat.
pna, to invert, go down.
pnk, to sprinkle; to capture.
pn-nu, a rat.
pnti, to detain.
prtis, Peritius (a Macedonian month).
ps, to cook; to stretch.
pst, the back, spine; to shine; yellow paint.
pt, a bow; shaft of a column; to shoot, extend.
pti, a foot; a bow.
pt-pt, to trample; put to flight.
ptr, to appear? to shoot.
pts, foot.
pn, to be; the.
pui, the.
pχa, lioness; gap; plank.
pχr, division; horizon.
pχt, to extend; to shoot.
pſ, to extend; light, to lighten.
r, fraction; chapter; mouth; kind of duck; to be, there is, it is; to, towards, for, by, in, of.

ra, sun; day; door; cell, mansion, prison; to receive; storehouse.
rabu, lion.
ramaχ, a monoceros.
ran, to please.
rf-rf, insect; worm.
rhi, garden, plantation.
rhn, dawn.
rk, to incline; chisel.
rka, impudent.
rkh, to burn; heat; a brazier.
rm, to weep, weeping; ray (fish).
rn, name.
rnn, to dandle.
rnnu, youth, young, to renew; flower.
rp, name of an animal.
rpa, one of a class; set over; a youth.
rr, child; to suckle; dandle.
rra, hog; a kind of snake.
rrk, kind of insect, centipede.
rru, nursling; boar.
rs, to suspend, hang, bow.
rt, race, men, mankind; foot; seed, to sow; sandstone; sculpture.
rta, to place, in order, when.
rtb, to beseech.
ru, door; mouth; snake.
ruma, man.
rut, to renew; sandstone; to germinate; to engrave; posterity; race.
rutn, to attack.
ruχau, heron, Ardea Nycticorax.
rχ, to speak, declare, acquaint; pure; pure spirit; to full, a fuller; to wash; a dream? cousin, relative.
rχ, pleasure; to delight.
s, she, her, it; a kind of duck; a person; a son.
sa, to drag; side; to drink.
saah, assembly.
sab, a jackal; a magus, counsellor; flute; ox; crafty.
sabu, a finch.
sabχ, to hurl.
sah, constellation.
sak, mystic animal, chimaera; to bind.
sapi, to form, mould, create.
sat, to sew; to hear.
satm, to hear.
sau, to drink.
sb, wall; star; flute; door; propylon; gate; the wicked; to adore; Saturn.
sba, flute; flute-player; wicked; prop; impious; son; behind.
sbaat, to be idle; to omit.
sbaau, to glorify; to praise.
sbak, to lay out.
sbhu, kind of bird.
sbk, crocodile; to subdue.
sbkt, cabin.
sbχ-t, gate.
se-menχ, to build.
seneba, to be strong.
setem, to hear.
sf, yesterday; sword; to cut the throat.
sfr, mystic animal, gryphon.
sf-t, pitch, bitumen; to cut, slaughter.
sfχ, seven; to overthrow, ruin, capture; impure garments? to noose; to overtake.
sha, to collect; a crowd; to encase.
s-haa, a stand for vases.
shh, bird, Porphyrio hyacinthus.
s-hm, to pound grain; to strangle.
s-hr, to frighten; terrify; to approach; to drink.
s-ht, to give light to.
sk, cabin; to molest; to be idle.
s-ka, to plough, scrape, play the harp, bind; to collect; a crowd.
skar, to cut, soothe, break in pieces.

sm, an instrument; to gather; fodder; to traverse.
sma, to tame, subdue; to rule, command; to smite.
smi, a fly flap.
smn, to set up; to prepare, lay out; goose; to establish.
sm-s, preferred, preference, minister.
sm-sm, minister.
smt, stibium.
sn, they, their; the hair; curl; to pass, traverse; to open.
sna, to bind, turn away; elbow; knee; brother, sister; to breathe, scent.
snaa, to polish.
snb, authority.
snf, blood.
snh, to bind.
snk, to lighten.
snkaus, to nourish.
snm, to chew, devour.
sn-n, to bind; orbit.
sn-nu, sacred cakes; loaf; to search, fish; to enclose; curl; sun's orbit. [adore.
sns, sns-hu, to give breath to; to
snsn, to sue, deprecate; a kind of
snt, cake; to found. [heron.
snti, sindon, flax; a shenti, shirt for the loins; to detain; to steal.
sntr, incense.
sn-ut, granary.
snχn, to nourish.
sp, a time; to leap.
sph, ribs.
spir, the side; to come to the side
spr, side. [of.
spt, hips.
sr, camelopard; sheep; kind of goose or duck; spike; arrow; fire; flabellum; to distribute; a chief, noble; to drink; cheese; to order, dispose, place [supply.
srk, scorpion; to breathe, scent,
s-rka, srta, to chisel, sculpture.
ss, a kind of wood; eight; to
s-sah, to assemble. [breathe.
s-sat, to be idle.
ss-i, flame.
ssm, a mare; a wood, sesamum; to scent, breathe; emerald.
ssn, to breathe.
ss-pu, jasper.
ssr, victory; to breathe.
ssr-t, to breathe.
st, odor; addle; rock; land; to extend; arrow; flame; ray, sunbeam; Seth, Typhon, ass; kind of duck.
sta, skein of thread; to sew; to tow a boat; coitus; gazelle; a mystic animal; to conduct; to spin.
st-aχmu, a bat.
sth, Cursorius Isabellinus.
sti, smell, stench; arrow; sunbeam.
stkn, to conduct, accompany?
stm, stibium; grand priest; to judge.
stp, approved, tried, select; to
s-tr, to deposit on a bier. [judge.
stut, to tremble.
stχa, woven things. [ley.
su, he, him, it; corn; wheat; barsua, the south; priestess; come
suaχ, to glorify. [along.
suh, an egg; nails.
sun-t, a king.
sunχ, to nurse.
sur, south.
suru, a bombicillo.
sutn, a king.
sut-ut, to extend.
sχ, to cut; to open.

sχa, to write; paint; to make; a
sχai, a scribe. [finch; a roll.
s-χar, to make.
s-χat, a hare.
s-χb, goading.
s-χbt, enamel, electrum; tin?
sχin, a lotua.
s-χm, to shut; the breast.
sχnt, a tunic.
s-χp, to bear off.
s-χr, to overthrow; a section.
s-χt, net; capsize, invert.
sχu, stick, kind of mace.
sχχ, sistrum; to play the sistrum.
sχχm, to rejoice.
s-ſ, to shut, bolt; a nest.
s-ſm, shrine. [escort.
t, thou, thee; feminine article; to
ta, the (fem. demonst. pronoun); to give; kind of crane; to go by boat; to carry; to offer; to sacrifice; the world; boat, barge.
taf, father.
takai, the adherer, a bat.
tam, kukufa sceptre; power; to
tam-ua, hair. [bear, carry.
tar, to grow; time.
tat, olive; oil.
tau, to burn.
taχ, the frontier.
tb, brick; finger; prætorium; kind of vase; box; to subdue.
tba, chest; sarcophagus; a wrap.
tb-h, a measure, weight, signet; a
tb-t, hippopotamus. [prayer.
tb-tb, to prostrate.
tb-ti, sandals; a prayer.
tf, father; to hoe; kuphi, perfume.
tf-tf, to drip.
th, latchet of a sandal.
tha, straw; to reel, be drunk, clip.
thni, forehead; to bow the forehead.
ths, to grease (leather); shoe-latchet.
th th, thti, lead.
thu, table.
thun, to rise up.
ti, a chief.
tka, flour; a spark; to adhere.
tkai, kind of bird; sale.
tka-r, to join or twist cords.
tm, no, not; the Recurvirostra Avocetta; to transport; to escape, avoid.
tma, to separate; distinguish; scatmat, to stupefy. [rify; subdue.
tms, a kind of bird.
tn, bent; conduct.
tna, half; a fortnight.
tnh, wing.
tnhu, prisoner.
tn-nu, to elevate, rise up; to send; to conduct; a chest; to move.
tnru, to break, smash.
tnt, Charadrius armatus.
tn-tn, to revolt; pride.
tp, to taste; cakes; to guess; to receive; hour.
tpak, a sail; kind of bull?
tph, cavern.
tpp, to taste.
tpt, boat; hull; cake.
tr, to transfix, bruise, rub; time; path? increase; to work, make, fabricate; shoot; whilst; to be;
trf, to dance. [to embalm.
trp, a wild duck.
ts, to distinguish; to suspend, sling, lead along; self; to transport.
tsm, a male cat?
tsnu, slice, cut.
tt, oil; hand; papyrus; to speak;
tta, eternal. [to establish.

ttfi, a reptile.
tts, lord; exalted.
tu, to pollute; a command; name of a region; a hill; to speak.
tua, to worship.
tuaua, to slaughter.
tuaut, green color?
tum, to place.
tut, a statue; some part of body.
tu-tu, pollute.
tχ, a weight; to disturb; appoint.
tχa, a fort.
tχn, an obelisk.
tχr, gore.
tχ-tχ, to order.
tſr, red; red crown.
u, to come, approach, unite, collect; [I, me.
ua, long, length, distance; a sacred
uaa, boat, barge. [boat.
uab, pure; priest.
uah, to pour out; feed.
ubn, light, to illuminate; brilliancy; to shine; a kind of game.
ubt, boiling.
ufa, to chastise.
uha, to stretch.
uhar, a dog.
ui, light, brilliancy.
ukar, a part of time.
'un, to shine, appear, light; to open; an hour; to be, being; a duckling. (Coptic, one.)
'un-nu, an hour; young.
'unun, name of a bird.
'unχ, a strap, girdle.
'unſ, wolf.
'ur, elder; crown.
'urr, crown.
'urri, war-chariot.
'urs, pillow.
'urt, placable, meek.
us, to saw.
usb, to stack corn.
usr, oar; defending.
ust, to eat?
usχ, large, broad; a saloon; boats of burden; holds; collar; to
'ut, to glow, light; green. [mow.
uta, to go out; to divide; between.
utau, a pectoral plate; kind of crane; the symbolical eye of the sun; a
'utb, to pour out. [pendant.
utbu, wells.
utn, consecration; ingot.
utn-nu, libation.
uts, to sustain, try, examine; to carry; to go out; palanquin.
utu, stern of boat.
uχ, pure, illumined; splendor; cere-
uſa, to eat. [mony.
uſau, darkness.
uſb, to answer.
uſm, ear of grain?
χa, altar; to resemble; a body; to measure; a thousand, many; to make; food. [chief, above.
χaa, born, to exist; dagger; first,
χab, hypocrite, cheat; a star.
χabsm, name of a spotted dog.
χabu, to mow.
χai, a cat.
χaibt, fan.
χaiu, altar.
χak, to shave.
χanru, to disperse.
χart, child, offspring.
χas, evil; wretched.
χast, some part of body.
χat, dead body.
χatab, pottery.
χatb, to fall.

χau, a cat; hypocrisy; length; al-
χaui, a sow; altar. [tar.
χb, to plough; wasp; Lower Egypt; papyrus; hypocrisy; deceit; to
χba, to plough. [violate; to dance.
χbb, the gullet.
χbni, to starve.
χbs, to clothe.
χbt, to dance, to tumble; iniquity.
χfa, fist, power.
χft, enemy, devil; when; a repro-
χi-χi, to mill, beat. [bate.
χm, no, not; to afflict; to bruise; annihilate; chest; hemp.
χmhu, to imagine.
χmi, enemy.
χms, flax; ear of corn.
χn, a breast; to bear? a child; to conduct; vestibule; likeness; to
χnark, to restrict. [place.
χnf, a kind of cake.
χnm, to seek? to smell? to sleep? a kind of nurse; brass; red jas-
χnms, a tutor. [per.
χn-nu, to conduct, send; a box.
χnp, to deliver; join?
χnr, cap, casque.
χns, to hunt.
χnt, to approach, tread on; entrance.
χp, a fist; a turn, as "once, twice."
χpf, part of a boat.
χpi, the winged uræated disk.
χpr, scarabæus; to exist; shape,
χprf, helmet. [type.
χpt, thigh; neophron duck.
χpχ, thigh; ursa major; scimitar; to smite with the scimitar.
χr, to, at, with, under; section; picture; to fall; to smite; child, offspring, youthful; leaf.
χrp, first, principal; to consecrate, offer as first fruits; paddle-blade; image. [or fodder.
χrf, bundle of arrows; truss of hay
χsbt, enamel, electrum? tin? blue.
χsf, to anchor a boat; go back; stop.
χsr, to disperse, clear.
χt, to navigate; shut; net; flame;
χtb, to tumble; to subdue. [other.
χtm, to shut; a fort.
χtmi, war-axe.
χtr, to consent.
χu, to rule, reign, direct; long.
χχ, gullet; to balance; to adjust;
ſ, pool, reservoir, tank. [to whip.
ſa, a cake, bread; first; high; festival; diadem; a bushel; book;
ſnau, boar. [wood.
ſakr, to adorn?
ſas, to run through, traverse.
ſasu, a shepherd.
ſat, to cut.
ſau, boar.
ſba, a slice.
ſbn, glass.
ſbt, porcelain.
ſbu, cords; kind of collar.
ſb-ſb, to transform?
ſf, a ram; to desolate.
ſft, to desolate; to fashion; a ram.
ſiu, long, when; power.
ſm, to arrange; to walk; bolt.
ſna, a net.
ſnti, tunic; apron; flax.
ſp, to take; an hour.
ſpn, a kind of bread or grain.
ſr, to smite; struck; a case; to-
ſra, a nostril. [wards; night.
ſrau, a child.
ſs, a kind of antelope.
ſsf, to turn back, stop.
ſta, shut, place; tomb; prison;
ſtrau, kind of antelope. [confine.

Stated Meeting, April 21, 1865.

Present eleven members.

Dr. Wood, President, in the chair.

Photographs of Rear Admiral Davis, Rear Admiral Dupont, Colonel S. H. Long, Captain T. J. Lee, Mr. Edward Everett, Dr. Franklin Bache, Major-General Humphreys, Brigadier-General Abbott, Brevet Major-General Totten, and Dr. Franklin (copied from the portrait in the Society's rooms), were presented by Colonel Hartman Bache. A photograph of Dr. Dohrn was received from Stettin, and one of Dr. Coates was presented by himself.

A letter was received from Mr. Charles Hale, Consul-General of the United States, in Egypt, dated Alexandria, November 1, 1864, enclosing a circular letter of M. Miani, dated Alexandria, 26th September, in reference to his proposed expedition into the interior of Africa, in the summer of the present year.

Monsieur le Consul Général:

Les voyages du soussigné dans l'Afrique centrale, pour la découverte des origines du Nil, sont déjà connus.

Après la publication de son paralèlle géographique contre Speke et Grant, tous les savants, qui ont mis en doute la découverte des Anglais, sont très favorables au soussigné, et par cette circonstance il cherche d'organiser une nouvelle expédition par souscriptions.

Venise, malgrè réduite dans un état déplorable, malheureuse mais toujour généreuse, a lui fait cadeau des verroteries, armes et munitions.

Des rivalités a lui fait refuser l'appui du gouvernment Egyptien, par conséquence, si Monsieur le Consul-Général aura la bontè d'envoyer aux sociétés savantes de sa grande nation, les cartes ci-jointes, peut-être qu 'on daignera agrandir ses moyens, et on devrait même lui donner un homme de quelque spécialité scientifique qui l'accompagne.

Monsieur le Consul-Général, implore la protection de votre patrie un homme qui est né Republicain, qui s'est battu à Venise pour la République, et quinze années se sont déja écoulées qu'il est protégé par votre noble nation.

Le soussigné sait qu'en Amérique la science n'a pas de patrie, et en attendant l'honneur qu'il demande, agreéz, Monsieur le Consul-Général, les sentiments distingués de gratitude de votre

Très humble et très devoué serviteur, MIANI.

ALEXANDRIE, 26 Septembre, 1864.

P. S. L'expédition aura lieu l'été de l'anneé prochaine.

Letters of invoice were received from the Natural History Society at Riga, September 13, the Royal Prussian Academy, November 11, and M. Des Moulins, dated Bordeaux, January 29, 1865.

Donations for the Library were received from the Prussian Academy and Horticultural Society at Berlin, the Natural Historical Society of Holland, the French Congress of Science, and M. Des Moulins of Bordeaux.

Pending nominations, Nos. 534 to 539, were read, spoken to, and balloted for.

Dr. Coates addressed the Society, inquiring what were the most appropriate means of showing its sympathy with the nation in its grief at the wicked assassination of the President of the United States, on the evening of Friday, 14th instant.

The President remarked that the mourning drapery which covered the chair of Dr. Franklin, used by the presiding officer at the meetings of the Society, had been ordered by the Society to be made for it at the time of President Jefferson's death, as he had recently observed in searching the old minutes.

Mr. Fraley moved that a committee of three be appointed to draw up suitable resolutions to express the sorrow of the Society.

The committee were appointed as follows: Mr. Fraley, Dr. Coates, and Mr. Price, who drafted the following preamble and resolutions, which were adopted:

The American Philosophical Society, uniting with the whole of the loyal people of the Union, deplore the sudden and violent death of Abraham Lincoln, the President of the United States, and deem it proper to perpetuate on their records their sorrow for this great national bereavement, and their estimation of the worth and virtues of the departed Magistrate and Man; therefore,

Resolved, That it is with unfeigned mourning we receive the dispensation of Providence, that has so suddenly and mysteriously permitted the removal of the Head of the Nation at a moment when he had apparently united all hearts in reliance upon his ability, wisdom, and mercy, and when all lovers of their country were rejoicing in the certainty of an honorable peace, and the restoration of the bonds of union and fraternal concord by his instrumentality.

Resolved, That the rebellion, which has caused the sacrifice of so many valuable lives and of so much property, and which has engendered so much sectional bitterness, crowned at last in its iniquity by the murder of the President, had its origin in a political and social system alien to the true principles of our National Government, subversive of human rights and human freedom; and its success would have been a great calamity, not only to the United States, but to the world.

Resolved, That bowing in humble submission to the dispensation that has not permitted Abraham Lincoln to close the war on the basis of mercy, charity, and amnesty, that he had publicly announced should be his guides to national peace and union, we trust that in the hands to which God has now committed the powers of the Government, justice shall be made potent to avenge the wrongs of the nation, and to give to mercy its appropriate power and place.

Resolved, That this Society will, by all its influence and power, support the Government in bringing the rebellion to an end, and in re-establishing the rule of the Constitution and the laws.

Resolved, That as a testimony of respect for the memory of the deceased Chief Magistrate of the Republic, the chair of the presiding officer of the Society be draped with mourning for six months.

Mr. Chase made a communication on the relation of magnetism and the magnetic declination to gravity.

In my first communication on the diurnal variation of the barometer [Proceedings A. P. S., IX, 284], I expressed the belief that a careful investigation would "show a mutual connection through which all the secondary [disturbing] causes may be referred to a

single force." In my various subsequent papers, and especially in the one to which the Magellanic Premium was awarded, [Op. citat, and Trans. A. P. S., Vol. XIII, N. S. Art. VI,] I pointed out various reasons for supposing that the primal unitary force is the same that controls the motions of the several stellar systems,—in other words, the force of gravitation,—or perhaps of simple undulation,—which is manifested as heat in one of its subordinate forms, and as attraction in another. The numerical relations which I demonstrated between the disturbances of weight and of total magnetic force, were certainly noteworthy, and to my own mind, extremely satisfactory; and as further investigations have afforded additional confirmation of my views, I desire to put upon record a brief notice of the general harmony which mutually characterizes the gravitation currents and the variations of magnetic declination.

Preliminary investigations showed, as might have been reasonably anticipated, that the best quantitative results can be obtained from the observations at stations near the equator, and I therefore based my reasoning, in great measure, upon the St Helena records, and Maj. Gen. Sabine's discussions, confirming it by such incidental references to other observations, as seemed available for the purpose. At the same time allusion was made [Trans. A. P. S., loc. citat., p. 182], to researches now in progress, which may probably enable us to discover numerical relations, that will be equally satisfactory, from an examination of the observations in higher latitudes. While patiently and confidently awaiting the completion of those researches, it may be well to present some considerations which will serve both as a corroboration of my own views, and as a guide to the investigations of others.

The discussions of the magnetic and meteorological observations at Girard College [Coast Survey Reports, and Smithsonian Contributions], should be specially interesting to all Americans, and they are also among the most recent and valuable publications on terrestrial physics. From them I quote the following references to the most important and best established normal disturbances of declination.

I. "The annual variation depends on the earth's position in its orbit; the diurnal variation being subject to an inequality depending on the sun's declination. The diurnal range is greater when the sun has north declination, and smaller when south declination; the phenomenon passing from one state to the other about the time of the equinoxes." [Part II, p. 10. See, also, Toronto Obs. 2, xvii, St. Helena Obs., 2, cxviii.]

II. "At the hour of 6 or 7, in the morning, the annual variation is a maximum, disappearing at a quarter before 10 A. M., and reaching a second (secondary) maximum value at 1 P. M. It almost disappears soon after 5 P. M., and a third still smaller maximum is reached after 9 P. M. Half an hour before midnight, the annual variation again disappears. At (and before and after) the principal maximum, between 6 and 7 in the morning, the annual variation causes the north end of the magnet to be deflected to the east in summer, and to the west in winter; at 1 P. M., the deflections are to the west in summer, and to the east in winter. The range of the diurnal motion is thus increased in summer, and diminished in winter; the magnet being deflected in summer more to the east in the morning hours, and more to the west in the afternoon hours, or having greater elongations than it would have if the sun moved in the equator. In winter, the converse is the case." [Ibid. p. 12. Compare St. Hel. Obs., 2, cxviii; Toronto Obs. 1, xiv, and 2, xvi.]

III. "According to the same authority" [Gen. Sabine], "the *annual* variation is the *same* in both hemispheres, the north end of the magnet being deflected to the east in the forenoon, the sun having north declination; when in the *diurnal* variation, the north end of the magnet at that time of the day is deflected to the east in the northern hemisphere, and to the west in the southern hemisphere. In other words, in regard to direction, the law of the annual variation is the same, and that of the diurnal variation the opposite, in passing from the northern to the southern magnetic hemisphere." [Ibid. p. 13. Comp. St. Hel. Obs., 2, lxxx, cxviii.]

IV. "The regular progression of the monthly values is a feature of the annual variation deserving particular notice. There is no sudden transition from the positive to the negative side, or *vice versâ*, at or near the time of the equinoxes (certainly not at the vernal equinox); on the contrary, the annual variation seems to be regular in its progressive changes. The method here pursued is entirely different from that employed by Gen. Sabine for the same end, but the results are, nevertheless, in close accordance." It has been found that the transition takes place "*ten* days after either equinox, and also that the turning-points occur ten days after the solstices." [Ibid. p. 14. Comp. St. Hel. Obs., 2, cxx.]

V. "The general character of the diurnal motion . . . is nearly the same throughout the year; the most eastern deflection is reached a quarter before 8 o'clock in the morning (about a quarter of an hour earlier in summer, and half an hour later in winter);

. . . the north end of the magnet then begins to move westward, and reaches its western elongation about a quarter after 1 o'clock in the afternoon (a few minutes earlier in summer). . . . The diurnal curve presents but a single wave, slightly interrupted by a deviation occurring during the hours near midnight (from about 10 P. M. to 1 A. M.), when the magnet has a direct or westerly motion; shortly after 1 A. M., the magnet again assumes a retrograde motion, and completes the cycle by arriving at its eastern elongation shortly before 8 o'clock in the morning. This nocturnal deflection is well-marked in winter, vanishes in the summer months, and is hardly perceptible in the annual curve. According to the investigations of Gen. Sabine, it is probable that, if we had the means of entirely obliterating the effect of disturbances, this small oscillation would almost disappear. In summer, when it has no existence, the magnet remains nearly stationary between the hours of 8 P. M. and 3 A. M., a feature which is also shown by the annual type-curve." [Ibid. p. 20. Comp. Hobarton Obs., 2, vi; St. Hel. Obs., 2, cxi, cxix, cxx; Toronto Obs., 1, xiv, 2, xvi.]

VI. "The critical hours which vary least during the year, are those of the western elongation, and those of the morning mean declination. The extreme difference between the value for any month and the mean annual value, is 31 minutes in the former, and 28 minutes in the latter." [Ibid. p. 21.]

VII. The curves of lunar-diurnal variation "show two east and two west deflections in a lunar day," the westerly maxima "occurring about the upper and lower culminations," and the easterly maxima "at the intermediate six hours. The total range hardly reaches 0'.5. These results agree generally with those obtained for Toronto and Prague." [Part III, p. 8. Comp. St Hel. Obs., 2, xxiii, lxxxii, cxliv; Toronto Obs., 3, lxxxv.]

VIII. In comparing the easterly and westerly curves, "the constant in Bessel's formula comes out zero, and hence it is inferred that the moon has no specific action in deflecting the magnet by a constant quantity." [Ibid. p. 10.]

IX. "If we take the four phases into account, the lunar action seems to be retarded ten minutes, which quantity may be termed the *lunar-magnetic* interval for the Philadelphia station. At Toronto, the intervals are not so regular." [Ibid. p. 11.]

X. "The characteristic feature of the annual inequality in the lunar-diurnal variation, is a much smaller amplitude in winter than in summer. Kreil, indeed, inferred from the ten-year series of the

Prague observations, that in winter the lunar-diurnal variation either disappears, or is entirely concealed by irregular fluctuations, requiring a long series for their diminution. The method of reduction which he employed was, however, less perfect than that now used. The second characteristic of the inequality consists in the earlier occurrence of the maxima and minima in winter than in summer. The winter curve precedes the summer curve by about one and three quarter hours." [Ibid. p. 12—13.]

XI. The curves of semi-annual variation, at all points where continuous observations have been made, present a striking similarity, the amount of deflection being nearly equal in all parts of the globe. [See diagram, Pt. II, p. 12. Comp. St. Helena Obs., 2, cxix; Toronto Obs. 2, xvi, xvii.]

Now it is evident that the mechanically-polarizing currents (Proc. A. P. S., IX, 367 sqq), must be variously deflected at different periods of the day, in consequence of the gravitation disturbances arising both from the varying distance of the sun, and from solar heat. Although it may sometimes be desirable to consider the so-called thermal currents apart from those which would be produced independently of any change of temperature, such a distinction is unnecessary in a preliminary qualitative investigation like the present, because the periods both of maxima and of minima are precisely coincident in the two currents (except as they may be slightly modified by the earth's radiant heat), and because *even the thermal currents are occasioned simply and solely by the varying gravitation* of fluids of varying density.

Regarding, therefore, the air and æther over any given magnetic meridian, during the day hours the intertropical, and during the night the extra-tropical, portions will be most drawn towards the sun, and the following deflections will be thus produced in the portions nearest the equator:

	6 to 12 A. M.	12 to 6 P. M.	6 to 12 P. M.	12 to 6 A. M.
Northern zones, .	S. E.	S. W.	S. E.	S. W.
Southern " .	N. E.	N. W.	N. E.	N. W.

The night disturbances, whether from variations of temperature, or from simple fall towards the sun (the distance fallen varying as the square of the time from midnight), will be very slight. The earth's rotation, centrifugal force, and atmospheric inertia, tend to throw each of the phases forward, and to increase the magnitude of the westerly, while they diminish the easterly deflections. If these

modifications were sufficient to override the slight easterly tendency at 6 to 12 P. M., and to advance the phases one hour, the disturbances would assume the following forms, the change between 7 P. M. and 1 A. M. being scarcely, if at all, perceptible:

	7 A. M. to 1 P. M.	1 P. M. to 7 A. M.
Northern zones, . .	S. E.	S. W.
Southern " . .	N. E.	N. W.

At the equinoxes, the amounts of deflection in the northern and southern magnetic hemispheres should be equal; at other seasons, the shortest lines would suffer the greatest displacement, the deflections being greatest in the northern zones from April to September, when the sun is in the northern signs, and in the southern zones from October to March, when the sun is in the southern signs. My experiments have shown that the compass-needle sympathizes with, and is, to some extent, controlled by purely mechanical vibrations; and if, in obedience to such control, it should tend to parallelism with the æthereal currents, a westerly disturbance of declination (the declination being always conventionally referred to the north pole of the needle), would correspond either to an equatorial southeasterly deflection of the southern, or a northwesterly deflection of the northern extremity of a half-meridian; and an easterly disturbance to a southwesterly deflection of the southern, or a northeasterly deflection of the northern extremity.

Substituting these declination values for the current deviations to which they correspond, the almost *precise* accordance of theory and observation in the prominent features of the normal variations of declination may be seen by a reference to the following table:

Daily maximum.* . . / Half yearly " Apl. to Sept.† / " " " Oct. to Mar.†	Easterly. / Easterly. / Westerly.	Westerly. / Westerly. / Easterly.	Morning Mean.	Evening Mean.	Stationary.
Theoretical, ...	7 A. M.	1 P. M.	10 A. M.	4 P. M.	7 P. M. to 1 A. M.
Observed [I to V].‡ . .	6-8 A. M.	1 P. M.	9¾ A. M.	5 P. M.	8 P. M. to 3 A. M.

Gen. Sabine, in speaking of the opposition of the annual and semi-annual curves (St. Hel. Obs., 2, cxix), says "these remarkable systematic dissimilarities, may be regarded as sufficient indications of a difference in the *mode of operation* of the solar influence in the two cases." I am not aware that any attempt has hitherto been made to explain this apparent difference, or to show that it is only

* In the northern zones. † Over the whole earth.

‡ The bracketed references are to the numbered quotations from the Girard College discussions.

apparent, and may result from the action of a uniform law. I believe that I have now given the needed explanation, and since I have shown experimentally that the phenomena are such as *should* be produced by gravitation, it is reasonable to assume that they probably *are* so produced. The probability is increased by the disappearance of the night oscillation in summer (V), the probability that when it is observed, it results from thermal disturbances, and the greater stability of those critical hours which are nearest to the hours of maximum sunward gravitation (VI).

The precise coincidence, both in time and direction, of the lunar-diurnal declination and tidal curves (VII), the unavoidable inference that the moon has no constant or specific magnetic action (VIII), the "establishment" of ten minutes at the Philadelphia station (IX), the correspondence of the lunar and solar curves in the diminished winter amplitude (X), and the uniformity at all stations of the semi-annual variation curves (XI), are all necessary corollaries of my hypotheses.

The demonstration of a connection between the daily and annual variations of magnetism and gravitation would be incomplete, if our theory could not be so extended as to explain the decennial and secular changes. For such an extension we are compelled to wait until further study and observation have more precisely defined the character and value of those changes, and suggested all the important gravitation disturbances of long period to which they may be plausibly referred. We may find, however, in the attraction of Jupiter, one of the possible causes of the 10–11 year period, while nutation, precession,* geological upheaval and depression, change of seasons, accumulation or diminution of polar ice, and the shifting position of the centre of gravity of our planetary system, must all necessarily contribute to the production of gradual changes in the terrestrial gravitation currents. The belief does not, therefore, seem unreasonable, that the feeble vibrations of the tremulous needle may not only furnish us with a delicate scale for weighing (as we have already approximately done), the huge mass of the sun, but they may also aid us in the discovery and verification of other important cosmical phenomena, and the assignment of their appropriate laws.

Although it is probable that terrestrial magnetism is mainly owing to currents circulating above the surface, it is well known that there

* Hansteen supposed that the motion of the magnetic poles was connected with the precession of the equinoxes.

are also earth-currents, which exert an appreciable modifying influence. I am confident that they will be found equally obedient to the laws of gravitation, which affect every particle of the earth's body, modifying the crystalline polarity and cohesion of solids as well as the flow of liquids, and producing internal tides, which may contribute largely to that metamorphism of stratified rocks which has been referred by geologists to the agency of heated fluids and vapors. (See Rogers, Pa. Report, 2,700; Lyell, Amer. Jour. of Science, [2], 39,22.)

The inclination presents some anomalies that are difficult to explain, and whether we compare the solar-diurnal or the annual curves at the principal northern and southern stations, the "indications of a difference in the *mode of operation* of the solar influence in the two cases" seem as striking and perplexing, as they did to Hudson and Herschel in their examination of the influence of heat on the barometer (Proc. A. P. S. IX, 283), and to Sabine, in his discussion of the semi-annual declination curves (St. Hel. Obs., 2, cxix). But the disappearance, in the progress of our investigations, of these once seemingly insurmountable difficulties,—the wonderful coincidence in the general features of the gravitation and magnetic currents,—and the *a priori* probability that all disturbed forces, of whatever character or variety, will tend constantly to a mutual equilibrium,—encourage the belief that this apparent paradox may be likewise susceptible of a simple interpretation which will drive it from its latest lurking-place.

I can think, at this moment, of no more probable causes of the want of symmetry here spoken of, than the different distribution of land and water in the two hemispheres, and the influence of powerful alternating land and sea breezes.* A long series of connected observations at a number of new stations may, perhaps, be required, before it can be satisfactorily ascertained whether the disturbances thus occasioned are sufficient to account for all the phenomena, but meanwhile it is interesting to observe the degree of accordance that exists at northern inland stations, like Philadelphia and Toronto, between the curves of vertical force and force of wind on the one hand, and those of horizontal force and barometric pressure on the other, as well as the agreement that has been pointed out by Dr. Lloyd and Mr. Homer, between the annual curves of declination and of temperature.

* The dependence of declination upon land lines and ocean currents, is shown by isogonic charts.

The ballot-boxes were then examined by the presiding officer, and the following gentlemen were declared duly elected members of the Society, viz.:

Mr. S. Austin Allibone, of Philadelphia.
Mr. Samuel F. Haven, of Worcester, Massachusetts.
Mr. Charles D. Cleveland, of Philadelphia.
Mr. James B. Francis, of Lowell, Massachusetts.
Mr. George C. Shafer, of Washington, D. C.
Mr. Timothy B. Conrad, of Philadelphia.

And the Society was then adjourned.

Stated Meeting, May 5, 1865.

Present ten members.

President, Dr. Wood, in the chair.

Letters accepting membership were received from S. Austin Allibone, dated 1816 Spruce Street, April 25; from Charles D. Cleveland, dated 248 South Eighth Street, April 26; from J. B. Francis, dated Lowell, May 1, and from S. F. Haven, dated Worcester, Mass., May 2, 1865.

Letters of invoice were received from the Society at Göttingen, February 13, and the Minister of the Interior at La Haye, March 13, 1865.

Donations for the Library were received from M. Miani, the Royal Society at Göttingen, the Geological Institute at Vienna, the King and the Natural History Society of Holland, the London Astronomical, Meteorological, Geographical and Chemical Societies, the Leeds Geological and Philosophical Societies, the Royal Societies at Edinburgh and Dublin, the Dublin Geological Society, and Quarterly Journal of Science; the Canada Survey, the Essex Institute, Rhode Island Society, Young Men's Association at Buffalo, Philadelphia Academy of Natural Sciences, Blanchard & Lea, Sherman & Co., Pliny E. Chase, and the National Academy of Sciences at Washington.

A photograph of Prince Maximilian, of Wied, was presented by Mr. Isaac Lea, for the Album.

The Library Committee made the following report through it chairman, Dr. Bell:

"At a special meeting of the Committee, May 5, 1865, the Librarian reported the second part of the Catalogue ready to go into the printer's hands, and made a statement of moneys already expended, and gave an estimate of the probable cost, at say $2.00 per page, for one hundred and fifty pages, more or less. On motion of Mr. Price, the Committee recommended to the favorable consideration of the Society the printing of Part II, consisting of Class V, that of the Historical Sciences. On motion of Dr. Coates, Pawson & Nicholson's bill, April 20, 1865, for binding, $27,20, was approved. The Librarian having presented a file of the Tribune, dating from the beginning of the Rebellion, as a donation to the Library, he was authorized to have it bound."

On motion of Dr. Hays, seconded by Mr. Lea, the question of postponing the printing of this second part of the Catalogue, in view of the probable reduction of prices, was referred to the Library Committee, with power to take order on the subject of their report.

Mr. Trego exhibited a copy of a very small tract, entitled "John Gordon's Mathematical Traverse Table, &c. Printed in the year 1758, and sold by Mr. Dunlap, in Philadelphia; Mr. G. Noel, in New York; Mr. B. Mecom, in Boston, and by the author," and said that it was probably the first edition of Gordon's method of land surveying, and of traverse tables, &c., after the invention of what is known in all the books as "the Pennsylvania method" of calculating areas by differences of latitude and departure.

Pending nomination No. 540 was read.

And the Society was adjourned.

Stated Meeting, May 19, 1865.

Present seventeen members.

President, Dr. Wood, in the chair.

Letters of envoi were received from Herr Von Limburg, Consul of the Netherlands, dated New York, March 5, and from the Secretary of the San Fernando Academy, dated Madrid, Dec. 28, 1864.

Letters of acknowledgment for the receipt of copies of the Transactions and Proceedings, were received from the following, Academies, Societies and Public Offices:—

Vol. IX, i, ii, XII, i, from the Central Physical Observatory of Russia, Dec. 2, 1863.
Vol. XII, iii, from the Dublin Geological Society, April, 16, 1864.
Vol. XII, iii, from the R. Society, Edinburgh, Jan. 4, 1865.
Vol. XIII, i, from Prof. Loomis, of Yale College, May 4, 1865.
Vol. XIII, i, from Harvard College, April 15, 1865.
Vol. XIII, i, from Boston Academy of Science, April 14, 1865.
Vol. XIII, i, from Lyceum N. H., New York, May 15, 1865.
Vol. XIII, i, from Dr. D. H. Storer, of Boston, April 13, 1865.
Vol. XIII, i, from the Astor Library, New York, April 18, 1865.
Vol. XIII, i, from Penn. Hist. Society, May 11, 1865.
Vol. XIII, i, from Library of Congress, May 3, 1865.
Vol. XIII, i, from Dr. C. M. Wetherill, April 18, 1865.
Catalogue, Part 1, from the Belgian Academy, Sept. 5, 1863.
Nos. 28 to 31–34, from Central Obs., Russia, Dec. 1863.
Nos. 61 to 66, from Central Obs., Russia, Dec. 1862.
No. 62 and title to VIII, from Prussian Academy, Nov. 30, 1864.
Nos. 68, 69, 70, from the Geological Society, Dublin, April, 1864.
Nos. 69, 70, from the Royal Society, Edinburgh, January, 1864.
No. 69, from the Royal Asiatic Society, Dec. 7, 1863.
No. 69, from the Royal Society at Göttingen, 1863.
No. 70, from the Geographical Society, Paris, Sept. 1, 1864.
No. 70, K. K. Geological Institute, Vienna, Sept. 26, 1864.
No. 70, Wm. Haidinger, of Vienna, Sept. 26, 1864.
No. 70, from Lyceum N. H., New York, March 27, 1865.
No. 70, from Zoological Society, Frankfort, A. M., Dec. 20, 1864.
No. 70, from Royal Academy at Bruxelles, Dec. 18, 1864.

No. 71, from Smithsonian Institution, Oct. 22, 1864.
No. 72 and List, from University of Toronto, March 23, 1865.
No. 72 and List, from Amherst College, March 21, 1865.
No. 72 and List, from Harvard College, March 20, 1865.
No. 72 and List, from Massachusetts Hist. Society, March 23, 1865.
No. 72 and List, from Boston Library, March 21, 1865.
No. 72 and List, from Lyceum N. H., New York, March 20, 1865.
No 72 and List, from George Bancroft, April 13, 1865.
No. 72 and List, from Yale College, April 12, 1865.
No. 72 and List, from Boston Academy, April 14, 1865.
No. 72 and List, from Astor Library, April 18, 1865.
No. 72 and List, from Maryland Historical Society, April 5, 1865.
No. 72 and List, from Chicago Historical Society, March 30, 1865.
No. 72 and List, from Dr. C. M. Wetherill, April 18, 1865.

A photograph of Dr. Augustus A. Gould was presented as a donation for the Album.

Donations for the Library were received from the Observatory at Cadiz, the Academy San Fernando at Madrid, the Geological Survey of Holland, the Museum at Cambridge, the Franklin Institute, the Historical Society at Philadelphia, and the Mercantile Library Association at San Francisco.

Prof. Cresson communicated his observations of the effects of the late destructive tornado, or series of tornadoes, which swept with such velocity and violence across Eastern Pennsylvania and New Jersey, in the afternoon of Thursday, the 11th instant, where he saw them along the line of railroad between Hackettstown and Hoboken.

All the trees seem to have been overthrown in a direction contrary to the course of the storm-wind, viz., with their heads towards the west. Mr. Trego described the storm as he knew of it in Pennsylvania, north of Philadelphia, and as far as New Hope, on the Delaware. Mr. Price described its ravages further west, accompanied as it was with much hail. Mr. Haldeman described it on the Susquehanna River, where it was also a hail-storm, and gave evidence to show that it originated on this side of the Alleghany Mountains. It seems to have traversed the whole space from Lan-

caster County to the neighborhood of the Hudson and the Atlantic shore in an hour or so.

Mr. Briggs gave a description of his recent visit to the Venango County Oil Region.

He described the discomforts of travelling to it, the crowds which filled it, the muddiness and general disorder which characterizes it, the reckless waste of money, time, and energy, manifest throughout it; the smallness of the average production of oil for the outlay, and, in his opinion, the entire absence of all reliable geological indicia for determining a good place for boring. He described minutely the method of constructing the derricks and boring machinery, and of using the tools in the process of boring, each of which he named, described, and exhibited in drawings, expressing his admiration of the practical tact which had been developed, the perfect adaptation of simple means to the desired end, and the rapidity and precision with which wells are sunk every day, which a few years ago would have been considered triumphs of the best engineering ability in Europe. The history, progress, and detailed method of each single Artesian well were, but a few years ago, considered worthy of elaborate illustrated publication. Now, in his opinion, at least two hundred such wells are being sunk all the time, with a simplicity of apparatus, and a speed and certainty of progress, which, although unrecorded, throws all former exhibitions of skill into the shade.

The daily present amount of petroleum reaching the depot of Oil City is about four thousand barrels, while not less than three thousand wells are in various stages of action in that part of the Oil Creek Valley, and those of its branches which lie within easy reach of Oil City. Of this amount, three thousand barrels are the production of a few large wells, leaving an average of say one-third or one-fourth of a barrel per day to the remainder; of this last number, he thinks not more than one well in twenty produces anything at all.

Mr. Briggs described, in addition to his former remarks, his visit to the Parkersburg region in Virginia, and the single instance which fell under his observation of a truly economical application of power by a company established twelve or fourteen years ago, whose numerous wells were all sunk and pumped by one engine, by means of horizontal rods led off from it in different directions between pairs of fence posts, from the caps of which swinging arms were hung,

the whole arrangement being used also for farming purposes, to serve as common field fences.

Mr. Lesley agreed with Mr. Briggs as to the total absence of all practical surface indications of a strictly local kind, available in even the slightest degree for determining the position of any well; and also in the opinion which Mr. Briggs expressed that the upland is as good oil-boring territory as the valley bottoms, the necessary addition to the depth of the well being of no practical importance.

He described and objected to such sections of the valley as that recently published in the Oil Region Atlas, and to the whole theory of valley-bed subsidence, faulty structure of the foot of the valley-walls, disturbed condition of oil regions, and other popular notions of surface disorder, considered as indications of the goodness of boring localities. He referred to the privately expressed opinion of a distinguished geologist, that the petroleum was pressed towards the valleys by the weight of the upland on each side, where the action had cracked the valley bed in the style of a floor-creep in a coal drift, and showed that it was improbable on the mechanical theory of the reversed arch.

He described the three great conditions for oil; first, an abundance of organic remains; secondly, a permeable and yet compact sandy or gravelly horizontal oil reservoir; and thirdly, a system of vertical oil reservoirs or open cleavage-planes, in polar directions, but confined to single formations, and having nothing whatever in common with the great faults which penetrate the earth crust in disturbed districts. He concluded that the general geological characteristics of an oil region were as fixed and reliable as the local surface indications were the contrary. He took the liberty of describing the yet little understood theory of M. Lesquereux (who had been prevented by circumstances from sending a memoir on the subject, to be read at this meeting), consisting essentially in the distinction between the genesis of coal from woody fibre, and the genesis of petroleum from non-fibrous vegetation, or marine fucus; and said that the Society might hope soon to have the explanation of this generalization in all its bearings from the eminent botanist who has done so much for the elucidation of the geology of the coal measures.

Mr. Chase described his late visit to some wells in Southern Pennsylvania, and showed how ignorantly the popular notion of three sandrocks was carried from the Venango to other and distant regions, and applied absurdly to a different geological condition of things.

Mr. Chase made a communication on the correlation of gravity with the vertical deflection of the needle.

A somewhat critical survey of the anomalies presented by the magnetic inclination, to which I referred in a former article (Proc. Am. Phil. Soc., April 21, 1865), has given me renewed reasons for regretting the want of a complete record of the investigations on which Prof. Secchi based his conclusion, that *all* "the phenomena hitherto known of the diurnal magnetic variations may be explained by supposing that the sun acts upon the earth as a very powerful magnet at a great distance."* As I know of no magnetic law which will account for those anomalies, I propose briefly to describe them, and to point out some relations between the gravitation currents and the *dip* of the needle, as a sequel to my papers on the influence of gravity upon the total magnetic force and the magnetic declination.

Gen. Sabine's discussions have shown some important points of difference between the magnetic disturbances at inter-tropical and extra-tropical stations, the Cape of Good Hope being magnetically, though not geographically, inter-tropical. In the third volume of the Toronto Observations, and in Prof. Bache's discussions of the observations at Girard College, projections of the daily and semi-annual inclination-curves are given;† and Plate V, of the second volume of the Hobarton Observations, contains a graphical representation of

* Phil. Mag. [4] IX, 452. Faraday (Exp. Res. III, 493) states "that the celebrated Prof. Gazzaniga, starting from his numerous experiments, which demonstrate the influence of magnetism upon the same aerial fluids, in a manner, therefore, different from that of Bancalari, was induced to consider the sun, and all the other celestial bodies, as so many enormous magnets, by which he established that attraction is merely one effect of the magnetism of the great celestial masses placed at an enormous distance,—an idea which reappeared in 1846 in Prussia, and in 1847 in France."

While admitting the intimate relationship of magnetism and gravity, I must dissent from the learned Professor's inference. For the evidence appears irresistible, that the earth's magnetism is directly dependent on the terrestrial gravitation of the thermally disturbed aerial currents, and that it is only slightly affected by the perturbations of solar and lunar gravitation, so that if we regard the relationship as a causal one, magnetism, rather than attraction, should be considered as the effect. (See Gauss' "General Theory of Terrestrial Magnetism," § 39, 40; Taylor's Scientific Memoirs, II, 232.)

† By the kindness of Prof. Henry, I have been permitted to refer to the proof-sheets of the Fourth Section of Prof. Bache's Discussions.

the diurnal variations of the inclination at the different observation hours in the four seasons. If we also project, from Gen. Sabine's tables of the mean results, the daily and semi-annual curves at St. Helena and Cape Colony, and compare the curves at the five stations, it will be found that,

1. The greatest daily disturbance of inclination occurs about noon.

2. At (magnetically) inter-tropical stations, the dip is diminished, but at extra-tropical stations it is increased in the middle of the day.

3. Increasing temperature and increasing solar altitude augment the inclination disturbance. This is shown both by the diurnal and the semi-annual curves.

4. As a corollary of propositions 2 and 3, at St. Helena and Cape of Good Hope, the inclination-disturbance is opposed to, and subtracted from the normal dip; but at Philadelphia, Toronto, and Hobarton the disturbance is added to the dip. Thus the inclination is

a MINIMUM at	St. Helena,	at 22—23 h.
" " "	Cape of Good Hope,	" 0— 1 h.
"MAXIMUM "	Philadelphia,	" 22— 0 h.
" " "	Toronto,	" 22—23 h.
" " "	Hobarton,	" 23— 1 h.

Reasoning either *a priori*, or from Secchi's postulates, we might naturally infer that the ellipticity of the atmosphere would be increased by the direct action of the sun, and that, consequently, from the tendency of magnetic parallelism to the gravitation currents, the dip would be augmented at noon in all places between the magnetic equator and the magnetic poles.

Mr. William Ferrel, in his paper* which furnished the first satisfactory explanation of the barometric depression at the equator and at the poles, shows that in consequence of the earth's motion fluids tend to assume a form similar to his Fig. 1 (Math. Monthly, I, 215), "*the surface of the fluid being slightly depressed at the equator, having its maximum height about the parallel of* 35°, *and meeting the surface of the earth towards the poles.*" The direct action of the sun, in increasing the equatorial ellipticity of the air, may also increase the tendency to equatorial and polar depression, and the magnetic parallelism may, therefore, be manifested in the solar-diurnal inclination-disturbance *precisely as it is manifested* at St. Helena

* "The motions of fluids and solids relative to the earth's surface." See Nashville Journal of Medicine and Surgery for 1856, and Mathematical Monthly for 1859, I, 140, sqq.

and Cape of Good Hope, by a diminution of dip between the parallels of 35°, and an increase in higher latitudes.

These coincidences may well suggest the need of more extensive observations in different parts of South America, Northern Africa, Southern Asia, the Pacific Ocean, and the Frigid Zones, to furnish the data for determining to what extent mountain ranges, coast lines, land and water radiation, winds, and ocean currents modify the theoretical phenomena of dip and declination.

By projecting on isoclinal and isogonic charts* the magnetic currents as indicated by the position of the needle in different portions of the globe, I have obtained the following results, which serve to show the character of some of these modifications:

I. Declination.

1. The currents manifest a tendency to follow the lines of most direct ocean communication between the warmest and the coldest portions of the globe, the general declination being westerly in the Atlantic, and easterly in the Pacific Ocean.

2. The lines of no variation are apparently determined in part by the land contours† that divide the waters of the globe into two great bodies.

3. The currents are deflected by the southern pointed extremities of the several continents, towards the east on the eastern shores, and towards the west on the western shores of New Holland, Africa, and South America.

4. The magnetic currents, in the three respects above enumerated, exhibit *a precise parallelism to the ocean tidal flow.*

5. In the comparatively narrow belt of the Atlantic Ocean, the declination between the parallels of 35° reaches 30°; in the broad expanse of the Pacific, the maximum within the same limits of latitude is 15°.

6. Between the parallels of 70° and 80° the declination becomes

* The charts that I used, were the polyconic projection of the "Lines of equal magnetic variation for the year 1858," which was constructed from Evans's English Admiralty Chart, for the United States Coast Survey Report of 1859, and No. 1 and 2 of the "Admiralty Manual for ascertaining and applying the deviations of the compass caused by the iron in a ship." 2d edition, 1863.

† The influence of coast lines in producing a tendency to equality of declination, is beautifully shown in the United States Coast Survey Chart of "Lines of equal magnetic declination on the Gulf of Mexico for the epoch 1860.0."

very great, and the currents tend to a gyratory or cyclonic motion, which appears to be modified by glaciers or local poles of great cold.

7. The cyclonic tendency is most marked in the southern hemisphere, where the ocean waters experience the least interruption to their normal motions. Mr. Ferrel's computation gives "28° 30′ for the polar distance of the parallel where the surface of the fluid, or the stratum of equal pressure, meets the surface of the earth."* It will be readily seen that at that distance the south pole is entirely surrounded by water, and it seems, therefore, highly probable, that if there were no land in the frigid zones, there would be no definite magnetic poles, but a simple polar belt towards which the magnetic currents would flow in parallel spirals,† except when deflected by land radiation, or tidal or other gravitation currents.

II. Dip.

8. The lines of equal dip are arranged in approximate parallels, around the two (principal) magnetic poles.

9. In consequence of this parallelism, they are convex towards the north in the Pacific Ocean, and towards the south in the Atlantic Ocean.

10. The magnetic parallels also approximate to the isothermal parallels, both in direction and in position, but with some important departures.

11. In South America, the magnetic equator is depressed nearly 30° south of the isothermal equator; it is, however, nearly equidistant from the (principal) north and south magnetic poles.

12. The magnetic parallels near the magnetic poles, are more convex than the isothermal lines, but they present some interesting instances of parallelism to the ocean currents, which are indisputably gravitation currents.

13. This parallelism is specially observable in the regions of the equatorial currents, the Gulf Stream, and the North Pacific and Japan currents.

14. If a series of waves were propagated through the air, from the magnetic poles to the equator, with slight deflections by the continental contours and ocean currents, they could be represented with great accuracy by the magnetic parallels.

All of the foregoing modifications, as well as the theoretical phenomena previously referred to, have their exact counterparts in the

* Loc. citat.

† This inference accords with Barlow's conclusion that every place has its particular polarizing axis.

currents which tend to restore the gravitation equilibrium of the air and water. It may be unwise, ignorant as we are of the true nature of causal efficiency, to assert that one form of force is produced by another, but it is one of the most important duties of true philosophy, to observe sequences and correlations. It has long been known that magnetic action may be so directed as either to assist or counteract the attractions of cohesion, chemical affinity, and gravitation; it has also been known that, under certain circumstances, disturbances of chemical or of cohesive attraction are accompanied by magnetical disturbances,* but I have now shown for the first time, by independent examinations of the total force, declination, and dip, that disturbances of gravitation are similarly attended.

It would certainly be very satisfactory, if it were possible, to have some means of exhibiting, by simple laboratory experiments, the direct and mutual convertibility of gravitation and magnetism, but I fear the attempt to reproduce, in any appreciable mechanical form, the magnificent and daily repeated operations in the laboratory of nature which I have feebly endeavored to interpret, must always be futile. In order to obtain even the small amount of disturbance (.00134) which I have noted in the half-daily variation of atmospheric weight (Trans. A. P. S., XIII, 121), it would be necessary to take observations at two stations, one of which should be 2.655†

* "A few years ago magnetism was to us an occult power, affecting only a few bodies; now it is found to influence all bodies, and to possess the most intimate relations with electricity, heat, chemical action, light, crystallization, and, through it, with the forces concerned in cohesion; and we may, in the present state of things, well feel urged to continue our labors, encouraged by the hope of bringing it into a bond of union with gravity itself." *Faraday: Exp. Res.* 2614.

† $R \times (\sqrt{D'} - \sqrt{D}) = 3963 \times (\sqrt{1.00134} - 1) = 2.655$. At Singapore the daily disturbance of total force is only $\frac{3}{4}\frac{1}{5}$ as great as it should be theoretically. I suspect that the discrepancy is owing mainly to the monsoons and other great temperature disturbances of the station, which shift the lines of force by a kind of conduction polarity. (Faraday, Exp. Res. 3279.) In other important respects there is a satisfactory correspondence between Singapore and St Helena. E. g.

	Mean Fall.	Mean Tide. (Theoretical × $\frac{3}{4}\frac{1}{5}$).		
		0 h.	6 h.	12 h.
Theoretical, . . .	8h. 29′	—.00031	—.000173	+.00064
Observed, . . .	8h. 23′	—.00031	—.000180	+.00064

(See "Numerical Relations of Gravity and Magnetism," Sections V, IX, and Faraday's Experimental Researches, III, 321—2.)

miles more distant from the earth's centre than the other. If the differences of vapor, temperature, barometric pressure, force and direction of wind, atmospheric electricity, &c., did not so complicate the problem as to discourage even the most sanguine experimenter from any attempt at solution, any result that could be obtained under such circumstances would give little general satisfaction.

It is possible, however, that the end, which we should vainly strive to reach directly, may be indirectly attained. Indeed, the various stages of an indirect road have long been known, but we have not been able to compare them by any common measure. The motion of gravity, by percussion or the obstruction of simple fall, has been repeatedly converted into the motion of heat; and the motion of heat, by the thermo-electric pile, has been converted into the motion of magnetism. The experiments of Barlow, Coulomb, Kupffer, and Christie,* on the influence of heat upon the magnet, furnish data that may lend some aid to any investigator who seeks to ascertain the precise value and modification of each force, in these successive conversions.

But I look most hopefully to researches that are based upon differences of specific gravity. Even the experiments of Barlow and others, to which I have just referred, as well as the electro-magnetic currents which are generated by chemical solution, involve such differences; the thermal aerial currents which harmonize with and increase the effects of simple gravitation towards the sun, are caused solely by the greater centripetal tendency of the cold, dense air which has the greatest specific gravity; and the recent investigations in thermo-dynamics, together with the experiments of Fusinieri and Peltier,† confirm the natural conviction that the imponderable agents can only be manifested through their influence on ponderable matter, and, therefore, under tendencies to equilibrium with the force of gravitation. I already find a curious approximate coincidence, to which I attach little importance so long as it is unsupported by corroborative evidence, but I refer to it as an indication of the very character that we might reasonably expect, and one that may possibly become valuable in the course of future research. The last edition of the Encyclopædia Britannica, Article "HEAT," gives for the expansion and consequent diminution of specific gravity between 32° and 212° Fahr., of

Iron, ...	$\frac{1}{819}$
Air, ...	$\frac{3}{8}$

* See Enc. Britan., 8th ed., XIV, 35—39.

† Taylor's Scientific Memoirs, III, 394.

If we suppose their specific magnetisms to be inversely proportioned to the disturbance of their specific gravities, we have, assuming the specific magnetism of iron as the unit,

$$\frac{3}{8} : \frac{1}{8\,1\,9} :: 1 : \frac{1}{3\,0\,7}$$

a value which is intermediate between those given by MM. Becquerel ($\frac{1}{8\,8\,2}$) and Plücker ($\frac{1}{2\,8\,7}$).* This result would be somewhat modified by an accurate determination of the ratios of the linear to the cubic expansions of iron in its several forms.

Faraday disclaims the assumption of any other than a conduction polarity of oxygen (2933, 2934), but that polarity is conveyed in lines strikingly analogous to the thermal gravitation currents (see Exp. Res., 2787, and III, Pl. IV, Fig. 6), which, in their turn, accurately represent the hypothetical indirect action of the sun on the needle, through the atmospheric affection of the lines of force (2936).

I know of no physicist who has given so lucid a theoretical explanation of the various magnetic perturbations, as the illustrious Fullerian Professor, and as his hypotheses appear to me still more satisfactory when viewed in connection with the gravitation disturbances, I will briefly refer to some of the more important points that have helped to confirm me in the various views that I have hitherto advanced. Such are, *e. g.*, the evidences of the identity of helices and magnets (2239); the existence of magnetic repulsion without polarity (2274); the relative magnetic position of gases and vapors (2416); the relations of the magnecrystallic, cohesive, and magnetic forces (2479, 2562, 2578); the probable dependence of the magnetic motions of fluids upon their mass and density (2768, 2769, 2781, 2863); the magnetic influence of winds and varying atmospheric pressure (2952, 2954);† the supposed velocity of magnetic transmission in space or æther (2958); the daily bi-polar minima of cold (3006); the closed circuits and prominent characteristics of the magnetic lines of force (3117, 3278, 3279, 3284); the tendency of all bodies to evolve electric currents, when moving in a magnetic field (3337); the relative diamagnetic and magnetic effects of heat

* Prof. Frazer has kindly referred me to the coefficients of dilatation for iron, in the "Artisan," of Dec. 1, 1860, and to the experiments of Regnault on the dilatation of air (See Jour. of F. Inst. [3], XV, 281). According to these data, the theoretical specific magnetism of oxygen would be between $\frac{1}{2\,9\,4}$ and $\frac{1}{3\,1\,4}$.

† Humboldt speaks of the accumulation of electricity in the lower equinoctial regions, "at the maximum of heat, and when the barometric tides are near their minimum." *Taylor's Scient. Mem.*, III, 398.

and cold upon air and the diamagnetic gases, as well as upon iron, nickel, and cobalt (2861, and III, pp. 446, 460, 464, 472, 473, 489, 490).

It should not be forgotten that there is no such thing within the compass of our observation, as "potential" gravity, no instance of matter in absolute rest, and just beginning or tending to move under a gravitating pull. Every particle of the earth, independently of the action of heat, chemical affinity, and cohesion, is at every instant subjected to four principal and important impulses, two towards the centres of the sun and earth respectively, and two tangential to the earth's orbit, and to its circumference. Of the several motions, the orbital one is by far the most important. Next in point of *velocity* is the one tangential to the circumference,—in point of *intensity*, the one towards the centre of the sun. Since the solar central and tangential motions are in equilibrio, it seems eminently proper that the others should be considered as disturbances, which tend, as I have elsewhere shown, to give a daily ellipticity to each section of air parallel to the equator. Not only are the barometric daily tides a necessary consequence of such ellipticity; owing to the difference of specific gravity, the cold air, in addition to the proper motion of convection, is alternately drawn towards and repelled from the earth's surface; and I am inclined to believe that many of the phenomena of the deposition of dew and the magnetic perturbations, which cannot be explained by other more important gravitation currents, may be thus accounted for.

Mr. Chase offered for publication in the Proceedings a revised list of trade tokens, numbering over two thousand, which, at his request, was referred to a committee of three, consisting of Mr. Peale, Mr. Price, and Mr. Lesley.

The minutes of the Board of Officers and Members in Council at their last stated meeting were read, and on motion of Mr. Peale, the Committee on the Hall was authorized to provide a fire-proof for preserving the most important papers belonging to the Society, at a cost not exceeding three hundred dollars.

Pending nomination No. 540 was read.

And the Society was adjourned.

Stated Meeting, June 16, 1865.

Present twenty members.

President, Dr. Wood, in the chair.

A letter was received from a committee of the Kensington Lodge, No. 11, I. O. of O. F., dated April 19, 1865, embracing the following preamble and resolutions:

Whereas, Our land and nation has been horrified by the cool and deliberate murder of Abraham Lincoln, President of the United States, at the hands of a desperate and bloody assassin, for no other cause than his unceasing efforts to re-establish the authority of the nation over the whole length and breadth of our wide domain, at a time when every patriot heart was filled with joy at the near prospect of peace, through the valor of our sons and our brothers upon the battle-field, while armed treason was bowing its head to the power of the nation, and trailing its hated flag in the dust; and

Whereas, As a part of that free people who placed in his hands the power with which he was intrusted for the good of the whole, we claim the right of expressing our grief at this national calamity, in the loss to the nation of a good kind heart, whose every beat was filled with love to his native land, and whose charity was wide enough to enfold every repentant sinner against the integrity of the government within its embrace; and of expressing our condolence with the family of our late Chief Magistrate, in the loss of the husband and father, endeared to them by his many sterling qualities of mind and heart; therefore be it

Resolved, That we deplore the sad event which has in a moment removed from us as a nation our head, beloved as he was by all for his sterling honesty and uprightness of character, and exhibiting as he did in his own person the true genius of American institutions, that no place is too high for the poorest of our people, if they are but true to themselves, and nurture and cultivate the generous impulses of heart and mind given by the Great Father of us all.

Resolved, That we extend our sympathy to the family of our deceased President, with the heartfelt prayer that He who tempers the wind to the shorn lamb may so temper this painful dispensation to

them, as "to work out for them a far more and exceeding weight of glory," and that our God will be "husband to the widow, and a father to the fatherless."

Resolved, That while we submit to this dispensation, we appeal to Him "who doeth all things well," that He would inspire the hearts of those who are in authority with that wisdom and grace that shall enable them to fulfil the duties that rest upon them in such a manner as will redound to the interest of our people, and assist in the work of establishing righteousness in the earth.

Resolved, That the regalia and emblems of the Lodge be clothed in the habiliments of mourning for the space of six months.

Resolved, That this preamble and resolutions be published in the Public Ledger.

Resolved, That a copy of the above preamble and resolutions be furnished the Philosophical Society of Philadelphia, signed by the proper officers of the Lodge, and attested with its seal.

(Signed) WILLIAM IRVIN, N. G.

JOHN T. BROWN, Secretary.

Letters of envoi were received from the Austrian Academy, February 1, the Prussian Academy, February 28, and the Society of Physics at Geneva, February 1, 1865.

A letter requesting information serviceable in cataloguing the Mercantile Library of New York City, was received, dated June 13, 1865, and the Librarian instructed to furnish the same.

Photographs of Dr. C. M. Wetherill, and Dr. Alexander Wilcocks, were presented for the Album.

Donations for the Library were received from the Academies at Berlin, Vienna, Dijon, Lille, and Boston; the Natural History Societies at Batavia, Geneva, Lausanne, and Boston; the German Geological Society, the London Astronomical Society, the Bureau des Mines, Franklin Institute, and Friends' Freedmen Association; MM. Elia Lombardini, A. Gaudin, and E. Durand, Dr. James Y. Simpson, Dr. Ed. Jarvis, Gen. H. L. Abbott, Rev. Albert Barnes, and Blanchard & Lea, of Philadelphia.

Dr. Geo. B. Wood read the following Obituary Notice of Dr. Franklin Bache.

When appointed by the American Philosophical Society to prepare a biographical memoir of its former President, Dr. Franklin Bache, I had already accepted a similar appointment from the College of Physicians of Philadelphia, of which he was Vice-President at the time of his decease. Believing the latter engagement to have the first claim upon me, I have already written and presented to the College a somewhat elaborate account of the life and character of our departed friend; and feel myself at a loss how best to prepare another, which shall have the merit at the same time of interest and of novelty. Indeed, I am not quite confident that I did right, when invited by the Society to undertake the duty, in not allowing it to pass into other and better hands; but I was influenced, in accepting the charge, by a well-founded conviction that Dr. Bache himself would have preferred that it should devolve upon me; and, moreover, by the consideration that, as there were two phases in his life, the scientific, namely, and the professional, so was there offered to his biographer the opportunity of presenting him to the future in two different aspects, one as he might be regarded from the standpoint of his connection with this Society, the other from that of his fellowship in the College of Physicians. It is in this spirit that the memoir referred to as having been already prepared was written; giving a general account of his life, but dwelling at greatest extent and with most emphasis on those incidents which were connected with his profession, and might be supposed to have a peculiar interest for the persons to whom it was addressed. On the present occasion, my wish is, in like manner, while giving a brief narrative of the events of his life, to dwell more particularly on such as have sprung from his connection with this Society, and will be likely more especially to interest its members.

The members of the American Philosophical Society need not to be informed that Dr. Bache was the great-grandson of its founder and first President, Dr. Benjamin Franklin. Sarah, Dr. Franklin's only daughter, was married to Richard Bache, an English gentleman, who emigrated, when a young man, to this country, from near Preston, in Lancashire, and became a citizen of Pennsylvania. The eldest child of this marriage, Benjamin Franklin Bache, was the father of our deceased fellow-member, who was born in Philadelphia

on the 25th of October, 1792, and, in consequence of the early death of his father, was, with several younger brothers, left to the care of their mother, aided, for a considerable portion of their minority, by her second husband, William Duane.

The early education of Dr. Bache was similar to that of most other youths destined for a liberal profession. He graduated in the department of arts of the University of Pennsylvania in 1810, and entering immediately on the study of medicine, went through a regular course of instruction, and received the degree of doctor of medicine in the medical department of the same school in 1814. In the preceding year, he had been appointed surgeon's mate in the army, and in the course of service, after his graduation, became surgeon; a position which he continued to hold until the then existing war with Great Britain closed, and for a short time subsequently. In 1816, however, he resigned, in order to engage in the practice of his profession in Philadelphia.

Dr. Bache exhibited a very early predilection for chemistry. Soon after commencing his medical studies, in the year 1811, he published, in the Aurora newspaper, an essay on the probable composition of muriatic acid, a question which long agitated the scientific world, and which, even after the discovery of chlorine, remained for many years unsettled. Dr. Bache seems to have been an early convert from the old hypothesis, which regarded chlorine as a compound of muriatic acid and oxygen, and the acid as yet undecomposed, to the new doctrine of Sir Humphry Davy, which taught that chlorine was simple, and muriatic acid a compound of it and hydrogen. Until the discovery of iodine and bromine, the close analogy of which with chlorine rendered infinitely probable a similar analogy in their relations with other bodies, no experimentum crucis had been made sufficient to satisfy all minds of the truth of the elementary doctrine; and it is a singular fact, that, in the almost countless ramifications into which the inquiry was pushed, explanation was in every instance possible as well upon the one as upon the other of these so different and even contradictory hypotheses. There are very few coincidences so remarkable in the whole history of the science.

In 1813, before his graduation in medicine, Dr. Bache published three chemical papers in the "Memoirs of the Columbian Chemical Society;" but of their special subjects I can say nothing, as I owe my knowledge of the fact solely to the private memoranda left behind by him, having never seen the book referred to. He appears to have

suspended his chemical studies upon entering the army, and not to have resumed them until after his return to Philadelphia, in 1816. But he must then have recommenced them with great ardor; for near the close of 1819, appeared his "System of Chemistry for the Use of Students of Medicine," an elementary treatise in one octavo volume of somewhat more than six hundred pages. This work was based upon Dr. Thompson's treatise, but contains much material industriously gathered from other sources, and, in its arrangement and execution, evinces so many of the characteristic traits of the author as fully to justify its claims to originality. Method, precision, accuracy, and simplicity, are its prominent features; and though, with the very great modification and vast expansion which chemistry has undergone since it made its appearance, the book, without very material changes, would not meet the present wants of the student, it was, nevertheless, when published, a good epitome of the science; and had it been favored by the influence of a great name, or high official position, might have been extensively used, and run through numerous editions. As it was, the sale of the book was not such as to make a reprint expedient; and at a later period of life, when the reputation won by Dr. Bache would have insured success, he could never be induced to put forth either a new work on chemistry, or the old one in a modified form.

His pen, however, was not idle. In 1821, in conjunction with Dr. Hare, he edited the first American edition of Ure's Dictionary of Chemistry; in 1823, prepared a supplementary volume to Henry's Chemistry, republished by Robert Desilver; in 1825, edited anonymously "A System of Pyrotechny," written by Dr. James Cutbush, of the United States Army, who died just as he had completed the manuscript; and in 1830, contributed to the "Philadelphia Journal of Health" an article on purifying and disinfecting agents, and edited the third edition of Turner's Chemistry. The last-mentioned work was an excellent elementary treatise, and exceedingly popular in the United States as long as the author lived. Dr. Bache edited four successive American editions; and there can be no doubt that he contributed much to its general acceptance in this country, by his most careful and conscientious revisions. It is not improbable that his esteem for Dr. Turner's work united with the repressive influence upon American authorship of the want of an international copyright law, to deter him from a renewed attempt to supply the public wants with a text-book of his own.

In consequence of the existing relations in reference to copyright between the United States and Great Britain, by which the English author is deprived of all protection here, and the American in England, great injustice is done to the writers of both countries. An English work is reprinted with us at the discretion of the American publisher, without payment to the author; and the cost is thus so much lessened, that the native author can compete with the foreign only by foregoing all compensation for his labor, or by producing a book much more acceptable to the public. The fault of this condition of things is exclusively our own; as the English government has shown itself not only willing but desirous of establishing the due relations by means of an equable international copyright law. But hitherto the supposed interests of the publishers, who can print without recompense to the author, and of the public, who are thus supplied with cheaper books, have outweighed with our legislators the claims of justice; and the consequence has been, as in the end it always will be, that the wrong has produced its legitimate fruit of evil; on the one hand overwhelming us with a cheap and pernicious literature, which is sapping the morals and vitiating the taste of the young, and on the other discountenancing domestic productions of a higher moral tone, and better adapted to our wants. Strange that the legislators, who can see clearly the propriety of protection to the manufacture of cloth, iron, and paper, are blind to the at least equal propriety of protecting against foreign interference the most important of all manufactures, that of sustenance and ornament for the mind!

From chemical authorship the attention of Dr. Bache was naturally turned to chemical teaching, and he began to lecture on the subject so early as 1821. Probably, in order to test his capacity before entering on a larger field, he made his first attempt in the presence of a class consisting exclusively of his brothers, sisters, and other near relatives; but soon afterwards he lectured to the private medical students of his friend, Dr. Thomas T. Hewson, and still later to a much larger class, composed of the joint pupils of two private summer medical schools, at that time established in Philadelphia. While thus teaching medical classes in the summer, he delivered, also, courses in the winter, first to the pupils of the Franklin Institute, in which he became Professor of Chemistry in 1826, and afterwards to classes of pharmaceutical students in the Philadelphia College of Pharmacy, by which he was appointed to the same professorship in the year 1831.

While thus engaged in teaching chemistry, both as a writer and lecturer, he did not neglect his professional business. To his private practice, which came very slowly, and never in a degree equivalent to his merits, were added, for several years, the official duties of inspecting recruits for the United States army, and of attending military officers who might happen to require medical aid when stationed in Philadelphia. He was, moreover, for a considerable time, physician both to the old Walnut Street Prison and to the new Penitentiary at Cherry Hill, to the former of which he was appointed in 1824, and to the latter in 1829.

Besides these avocations, which yielded him more or less income, he was for a period of six years, from 1826 to 1832, engaged, with several others, in gratuitously conducting the North American Medical and Surgical Journal, one of the best medical periodicals then existing, which occupied much of his time and thoughts; and in the year 1829, he entered upon another course of unpaid labor, on the part of the College of Physicians of this city, in revising the United States Pharmacopœia, which was repeated every ten years as long as he lived.

Nor did he confine himself, at this period of his history, exclusively to chemical and professional labors. His situation, already referred to, of physician to the two State Prisons, the Walnut Street Prison, conducted on the old collective principle, and that at Cherry Hill, on the new Pennsylvania system of solitary confinement, not only suggested inquiry into the general subject of penitentiary discipline, but gave him excellent opportunities of comparing the two systems, and of determining their relative value. With one of his thoughtful turn of mind, such inquiries almost necessarily matured into decided opinions, which deserve great weight, in consequence not only of his opportunities, but also of his excellent judgment. His views on the subject were given in two letters to Roberts Vaux, well known as a zealous advocate of the modern plan, which were published in the third and sixth volumes of Hazard's Register, and also separately in a pamphlet form.

Of these two letters, the first presented the evils of the collective or gregarious system, as he had observed it in operation in the old prison, and those of the solitary system, as alleged by its opponents, with comments of his own, which lead necessarily to the conclusion that the latter is far preferable to the former in most points, and scarcely inferior in a single one. The second letter gives the results

of one year's personal observation of the working of the new plan in the Cherry Hill Penitentiary, which abundantly confirmed the previous conclusions of his judgment. It must be understood, however, that he distinguishes very decidedly between the plan of entire seclusion, without occupation for mind or body, and that in operation at the new prison, which, while most carefully debarring the convicts from all intercourse among one another, whether by night or day, permits a cautiously regulated intercourse with others, and gives every facility for needful exercise, useful labor, and profitable reading. It is the latter system only that he commends, abandoning the former, apparently without reserve, to the very serious charges, made by the enemies of solitary confinement, of inflicting tortures of mind conducive to insanity, and most deleteriously influencing the physical health, by the deprivation of fresh air and exercise, and all mental recreation.

In the year 1818, soon after having established himself as a practitioner of medicine in Philadelphia, Dr. Bache married Aglae, the daughter of Jean Dabadie, a French gentleman then resident in this city. Perhaps by the merely worldly-wise this may have been regarded as an imprudent step, as their united incomes were insufficient for the support of a family; and for many years, with all that he could add to that income by his best exertions, the young couple labored under many difficulties from deficient means, which were, of course, aggravated by the constantly increasing family that was growing up around them. Nevertheless, I have no doubt that he acted most wisely; for the match was one of affection; the lady was intelligent, amiable, and in every way worthy of him; and it is impossible to overvalue the influence of mutual love in estimating the sources of happiness in this world. What, if borne singly, might be regarded as trouble or misfortune, when shared with an affectionate partner often scarcely deserves the name, and sometimes may be even looked on as a blessing, as it calls qualities into exercise which might otherwise have remained dormant, and which, when developed, are alike a cause of happiness to their possessors and their objects, and an honor to our nature. Unhappily, Mrs. Bache, after bearing with her husband the difficulties of his earlier career, was called away from him just as his pecuniary affairs were beginning to be no longer a source of anxiety. She died of consumption in May, 1835, leaving him, as her best legacy, a young family of sons and daughters to give exercise to his affections, and comfort to his declining years.

The period in Dr. Bache's history which we have now reached, may be considered as a resting-point, from which he may have looked back with a feeling of satisfaction for time well spent and work well done, but as yet with little consciousness of having filled a large space in the public eye, or having done much that was obvious for the general good. Hitherto he had been serving an apprenticeship to the great business of life, and preparing himself for the works which were to entitle him to rank among public benefactors, and to earn for him a lasting name. The most important of these labors were mainly professional, and have been fully considered in the memoir to which I have already once or oftener alluded. I shall speak of them here, as a general rule, only so far as may be necessary to keep the thread of the narrative unbroken; dilating, however, upon those points which especially connect him with this Society. I do not mean to intimate that there was any sharp or precise line between his earlier and later career; so far from this, I am even unable to fix upon the year when the one may be said to have ended and the other begun. But we may date the commencement of the second era from the time when he had fully engaged in the work of revising the United States Pharmacopœia, had been made Professor of Chemistry in the Philadelphia College of Pharmacy, and was about to begin the work of preparing the United States Dispensatory; between the close of the year 1829 and the beginning of 1832, when he was approaching his fortieth year, and had fairly entered into middle life.

I shall treat first of his relations with this Society, with which he was so long and so intimately associated. He was elected a member on the [redacted] of April, 182[redacted] For several years there is little evidence, in the minutes of the Society, that he participated actively in its proceedings otherwise than by attendance at its meetings; the only office filled by him previously to the year 1825 being that of judge of the annual election in January, 1822. He was too modest to draw attention to himself by any premature display; so that, in looking over the records, I have noticed only a single instance, during the first five years of his membership, in which he appears to have departed from his rule of silence; and, in this instance, it was nothing of his own that he offered, but a paper by Mr. Henry Seibert, containing the results of an analysis of a specimen of fluosilicate of magnesia from New Jersey. In the regularity of his attendance he was very remarkable, from the date of his election to that of his decease; and certainly, during this long period, there was no other member of the Society who was present at nearly so many meetings

as he. A record of attendance has been kept by the Treasurer since the beginning of 1850; and from that year, inclusive, to 1864, which was the last of Dr. Bache's life, his average yearly attendance, notwithstanding an absence from the country on one occasion of five or six months, was fifteen meetings, the whole annual number being twenty. The only other member who, during this period, exhibited so fair a record, or even an approach to it, was our worthy Treasurer himself, whose favorable line of marks for most of the time was almost without a flaw.

In January, 1825, Dr. Bache was elected one of the Secretaries, and he continued to serve the Society faithfully in this capacity until January, 1843, having been the senior Secretary for eleven years. For a considerable portion of the same time he was one of the Standing Committee of Publication, having been appointed a member of the Committee in 1826, and its chairman in 1829; and he continued to act in the latter capacity until January, 1835, when he declined a reappointment. They who knew Dr. Bache do not require to be informed how sedulously he fulfilled the duties of this laborious Committee, not only taking care that everything should be done in its proper time and place, but also that it should be correctly done; and I do not venture much in saying that, through the long series of our Transactions, none will be found more free from errors of the press, or any other errors which fall within the scope of the Committee's oversight, than the volumes published under his superintendence.

At the election of January, 1843, he was chosen one of the Vice-Presidents of the Society, and, being re-elected annually, became senior Vice-President in 1849. This relative position he continued to hold until January, 1853, when, Dr. R. M. Patterson having on account of his failing health declined a re-election, he was chosen President; thus having risen regularly through the successive grades of office to the highest, as if the Society, in its relations with him, had participated in that spirit of order by which he was himself so strongly characterized. During the first year of his presidency, he paid, with myself, a visit of five or six months to Europe. On this occasion the Society furnished him with a circular to its correspondents abroad, which facilitated his intercourse with scientific men, and would have been still more useful, had not the necessary rapidity of our movements very much curtailed his opportunities for such intercourse. But throughout the journey he kept the good of the Society in view, searching for information about its foreign members, endeavoring to awaken an in-

terest in its affairs among those he was happy enough to meet, and seeking to extend its relations, both with individuals and associations, whenever apparently desirable. After his return, he gave, December 16th, 1853, an address to the Society in relation to its affairs, an abstract of which is contained in the published Proceedings of that year. In consequence of a by-law then existing, "that no person should be eligible as President at more than two out of three successive elections," he ceased to hold the office after January, 1855. Believing that this rule did not work beneficially for the Society, he introduced a resolution, November 5th, 1858, after the decease of the late President, Judge Kane, for the repeal of the by-law, which at the subsequent meeting was carried by a majority of 23 to 2. Before initiating this measure, he had firmly resolved not again to accept the responsibilities of the position; and, though the general feeling of the members was, I believe, in favor of his re-election, and he was strongly urged to permit himself to be considered as a candidate at the approaching election in January, 1859, he adhered to his resolution, and continued a private member during the residue of his life. His interest, however, in the Society, in no degree abated; and he continued to be as assiduous as ever in his attendance at the meetings, and as actively participant in the proceedings. How much the Society was present in his thoughts, may be inferred from the fact, that, on his death-bed, just before his intellect was swallowed up in stupor, he spoke to me of a measure then under the consideration of the Society, which he feared, if adopted, might prove injurious to its interests; and these were among the last intelligent words that he uttered.

In the course of his membership, Dr. Bache rendered several important services to the Society, which are worthy of being recalled. The first that I shall notice concerned the catalogue of members. Soon after he was first chosen one of the Secretaries, it was resolved, at his suggestion, that such a catalogue should be prepared by these officers; and ever afterwards he appeared to take it under his special guardianship, being always solicitous that it should be at once complete and correct, with every name properly entered, and every date, whether of the election, resignation, or decease of a member, accurately stated. On the last point he often took great pains in making inquiries, especially as to the foreign members; and in regard to the subject generally, there was no one, I presume, who nearly equalled him in a careful watchfulness over the necrology of the Society, the

whole number of deaths, reported by him as they became known, scarcely falling short of one hundred.

Another service had reference to the proceedings of the Society. Except as regarded the papers published in the Transactions, these proceedings were formerly almost barren of useful results outside of the comparatively small number of attending members who participated in them. At the meeting of May 18th, 1838, a committee was appointed upon the motion of Dr. Bache, of which he was chairman, to consider the propriety of publishing an abstract of the proceedings; and at the next meeting, upon the favorable report of the committee, the proposed measure was adopted, and the Secretaries were instructed to appoint one of their number as Reporter. Dr. Bache was accordingly appointed to this office, and at the meeting in August following, the first two numbers of the printed Proceedings were laid on the table. Having completed the Report for the year 1838, he resigned the post in favor of one of the other Secretaries, but in 1842 was again appointed, and served for another year.

The arrangement of the Franklin papers is another result which may be fairly ascribed to him. As they came into the possession of the Society, these papers were in a chaotic state, which rendered them almost useless for reference. In November, 1849, Dr. Bache introduced the subject to the notice of the Society; and at the following meeting in December, was made chairman of a committee, with instructions to have the papers arranged in chronological order, and divided into volumes of a convenient size for binding. A little examination sufficed to convince the committee of the almost Herculean character of the task confided to them; and, on their recommendation, it was determined that the labor should be intrusted to some competent person, to be duly compensated. It was estimated that the papers would form at least sixty respectable folio volumes; and as ten dollars per volume was deemed but a moderate recompense for the requisite labor, the sum of six hundred dollars was appropriated to defray the cost. The task was undertaken by our Treasurer, Mr. Trego; but so complicated and tedious did it prove, that, though he devoted to it most of the time he could spare from other avocations, it was completed only a short time before the decease of Dr. Bache. I have been told that one of the last acts of our departed friend was to appoint a meeting, with a qualified person, in order to make arrangements for the binding of these volumes; but he was prevented by his illness from fulfilling the appointment, and the work still remains to be done.

Yet another service meriting special notice was his participation in the business of newly arranging the library of the Society, and preparing a catalogue; a duty which fell to the lot of our present Librarian, and has been so well performed by him. Towards these purposes, Dr. Bache made the liberal contribution of five hundred dollars on two successive occasions, in the years 1853 and 1854, which is to be valued the more, as it proceeded not from superfluity of means, but from an income which, though considerable at the time, was all needed, in order to make prudent provision for the future of his family.

I might extend these remarks concerning the relations of Dr. Bache with this Society much further, but all the more prominent facts, so far as they have come to my knowledge, have been detailed; and I am warned by the time already consumed that I must hasten on, if this address is to be completed within the customary limits.

It has been already stated that, in the year 1829, Dr. Bache became engaged, with others, in the laborious duty of revising the Pharmacopœia of the United States. He entered upon that duty as one of a committee of the College of Physicians of Philadelphia; and afterwards served on another committee appointed by the Medical Convention which met at Washington in 1830, whose duty it was to further revise and ultimately publish that important work. At three decennial periods subsequently, 1840, 1850, and 1860, he was engaged in the same manner, in the same work, and on the last of these occasions, acted as chairman of the Committee of Revision and Publication, and consequently had the chief laboring oar. Except by the medical gentlemen present, the work here referred to can scarcely be appreciated in regard either to its importance, or the amount of labor involved; but some idea may be formed on both these points, when it is understood that the Pharmacopœia is a national code, essential to the maintenance throughout the country of a certain uniformity in the nomenclature and preparation of medicines, without which every member of the community would be liable to serious accidents to his health and life; and that in each revision of it, many months, and sometimes even years, are occupied with more or less work every day, to fit it for the purposes it has to fulfil. In Europe this duty is generally performed under legal sanction, and by compensated labor. With us the Pharmacopœia rests entirely upon opinion, and all the labor bestowed and time consumed are wholly gratuitous.

Immediately after the publication of the first revised edition of the

Pharmacopœia, in 1831, Dr. Bache, jointly with myself, undertook the preparation of the Dispensatory of the United States, which was completed and published in 1833. I am precluded, by my share in the authorship of that work, from treating either of its merits or demerits. This much, however, I may be permitted to say, that it purports to represent the existing state of Materia Medica and Pharmacy, has been accepted in this capacity to a great extent throughout the United States, and has been used as a guide in relation to these branches of medicine by a large proportion of the physicians and apothecaries of our country. The extensive use of the book rendered frequent editions necessary, and thus gave opportunity for revisions at short intervals, by which its character as a representative of the knowledge of the times has been maintained. Indeed, before the decease of Dr. Bache, so many changes had been made, and so much novel matter introduced, that it had become almost a new work, possessing little more than the general features of the original. Between the years 1833, when it was first published, and 1864, when Dr. Bache died, it went through eleven editions, at average intervals of three years; having, during this time, swollen from somewhat more than a thousand to nearly sixteen hundred pages, and containing, from its greater compactness, almost twice as much matter as in the beginning. From this statement it will be understood how great an amount of labor must have been bestowed on it from first to last by Dr. Bache, and how constant a source of occupation it must have been to him during this long period of more than thirty years. Happily the pecuniary results were such as to make his income, much restricted anteriorly to its publication, comparatively easy from that time onward, and quite adequate to his wants. The work was, moreover, a stepping-stone to his appointment to the chemical professorship in the Jefferson Medical College, which he received in 1841, and continued to hold as long as he lived.

The vicissitudes of his life seem to have ceased with this appointment. Made by it not only comfortable but even affluent in his circumstances, he was no longer compelled to search for new and better position; and as his time and powers were sufficiently occupied in the performance of his regular duties,—the care, namely, of his practice, the fulfilment of his professorial functions, and the constantly recurring labor of revising either the Pharmacopœia or the Dispensatory,—he had no inducement to new attempts at authorship, or in any other direction to seek for new fields of industry. As a member of the Wistar Party, and the Senior Medical Club, he performed

duly his function whether of host or of guest; participated in our anniversary Philosophical Dinners, then more fashionable than now; in all respects acted duly the part becoming his social position; and gave to the various associations and institutions, benevolent, scientific, or professional, with which he was connected, the proper share of time and attention. Thus fully occupied, without being overworked, with no serious drawback to his comfort, he was, perhaps, as happy as is consistent with this uncertain state; and the current of his life, though somewhat agitated in its earlier course, now flowed onward copiously, richly, and smoothly to its end.

Having sufficiently detailed the incidents of his career, it only remains that I should endeavor to portray his qualities as a man. Of his personal appearance nothing need be said, as there is no one here, I presume, not perfectly familiar with it. His mental qualities, though not peculiar in their nature, were in some respects strikingly so in degree, so as on the whole to constitute an extraordinary character. With little of the imaginative or inventive faculty, he had an excellent reason and judgment, and at least an average power of observation. He therefore seldom sought or made discoveries, never formed theories, except as convenient categories for facts, and generally eschewed figures of speech and flights of fancy, whether in speaking or writing; but he was almost always clear in thought and correct in conclusion, remarkably sound in his opinions, and seldom wrong in his judgments either as to the character and probable actions of men, or as to what was expedient under any given circumstances. In mental action, as in his bodily movements, he was remarkably slow and deliberate, but was, therefore, all the less liable to error; and when his conclusions were once attained, he was even more slow to change than he had been to form them.

Though generally serious in thought and manner, he was possessed, in no slight degree, both of the sense and faculty of humor, which often rendered him a delightful companion; but his pleasantries partook of the quietness of his general deportment, were never boisterous or offensive, and rarely, if ever, out of place. There was a singularly marked line of division between his serious and lighter veins; and, unlike many wits who never hold back a ludicrous thought, however grave the occasion, he almost never mixed the two together. I have not known an individual who better illustrated the adage, *sapientis est desipere in loco;* who better knew, or, perhaps, I should rather say, more accurately felt when it was proper to be sober, and when to be gay and playful.

But it was more in his moral than in his intellectual character that his peculiarities lay. Dr. Bache was apparently, rather by nature than by education, eminently conscientious. To believe that anything was right was, with him, as a matter of course, to act accordingly. The idea of doing what he believed to be wrong would seem not to have occurred to him; and the attractive appeared to lose its character when dissociated from the right, and to be no longer even tempting.

He had, moreover, a natural love of truth, justice, and method, perhaps essentially the same mental quality, differing only in application, as all are resolvable into the simple love of order; truth being the due relation of things in regard to fact, justice in regard to compensation or reward, and method in regard to position; so that one who by nature is very fond of order, will be apt to be true and just as well as methodical, unless perverted by accidental counter-influence. At all events, our deceased friend had all these qualities in an eminent degree. I never knew him to tell or even hint an untruth, to do an unjust act, or knowingly cherish an unjust thought; and every one acquainted with him, ever so slightly, must have been struck with the remarkable method and precision which pervaded all that he said or did.

A natural consequence of his truthfulness was a remarkable degree of candor, which, though perhaps not obvious to strangers, because both his good sense and a becoming modesty withheld him from intruding his personal concerns upon those of whose interest in himself he was not confident, and with whom, therefore, he may have sometimes had the reputation of reserve, yet to his friends was well known, and was among the most attaching features of his character. In relation, however, to the concerns of others, he was as reticent as he was open in reference to his own; and I do not believe that he ever violated, even accidentally or carelessly, any confidence reposed in him.

Another conspicuous moral trait was a placidity of temper that was proof against almost any provocation; not that he did not feel an injury or injustice done, whether to himself or others, and express himself accordingly; but the feeling provoked was rather that of regret than of anger, and the offence was readily forgiven when not attended with some moral obliquity.

Taking him altogether, I never knew a man with a better balanced mind, or one who more nearly approached to my notions of perfection in all that concerns the moral character. As a consequence of

his various excellences, and certainly without any purposed action of his own, for with all his amiable qualities he was remarkably independent, he conciliated almost universal good-will; and few men have been more generally esteemed, and, where well known, better beloved than he.

Dr. Bache's writings and public teaching were marked by his characteristic intellectual traits. Simplicity, clearness, truthfulness, accuracy and method were their chief qualities, in regard both to material and arrangement. Correct reasoning and sound judgment were also evinced whenever there was occasion for their exercise. His style was easy and remarkably correct, even to the punctuation, and his language pure, idiomatic English. His published writings are entirely exempt from any appearance of effort or attempt at display. The purely ornamental is eschewed entirely. Figures of speech, flights of fancy, and flowers of rhetoric, are unknown to them.

It may seem strange that one so addicted to science, and especially to chemistry, as he, should not only not have made any remarkable discovery, but should not even have exerted himself in the line of experimental research; but to the discoverer, except in the fields of pure natural history, where observation is the great requisite, a certain amount of the imaginative faculty, and of the disposition to its exercise, which is apt to attend its possession, is, I believe, an essential requisite; and of this, as before mentioned, Dr. Bache had very little. To find out the new, one must be able to penetrate somewhat into the unknown. The discoverer must have an imagination that shall carry him beyond the present, and suggest new ideas and new trains of thought; and, though these are not discoveries, yet they become so when, having been submitted to the test of experiment under the guidance of reason and judgment, they may either be found to be themselves truths, or paths which lead to truth. A combination of these powers, the imagination, reason, and judgment, is essential to make a great discoverer or inventor; and of the three, a certain degree of the first is indispensable, outside of the field of pure observation, unless as the result of mere blind accident.

From 1841 to the time of his decease, Dr. Bache's course of life was, so far as I know, distinguished by no prominent incident beyond those connected with his regular engagements, except a journey in Europe, made with myself in the spring and summer of 1853. It was my original intention, in preparing this memoir, to incorporate with it a brief abstract of that journey, which was certainly con-

sidered by Dr. Bache as representing one of the most interesting eras of his life; but the length to which this address has been already protracted, and a glance at my notes of the journey showing me that it would be impossible to compress what I should have to say within very narrow limits, have warned me that I must forego the execution of this intention.

In the spring of 1864, just as he was about to enter upon the task of preparing a new edition of the United States Dispensatory, which he expected to be peculiarly laborious, he was seized with an illness that proved to be his last. After considerable suffering for two or three days, his pains left him almost entirely, and in a few days more he sank into a state of prostration and stupor, which terminated in a perfectly easy death, on the 19th of March, somewhat more than a week from the commencement of the disease. He was in his seventy-second year when he died.

A memoir was presented for publication in the Transactions, by the Secretary, from Dr. Leidy, entitled "The Myriapoda of the United States, by Dr. H. C. Wood, Jr." The Secretary stated that the original MS. had been burnt in the late conflagration of the Smithsonian Buildings, at Washington, and that the present had been newly prepared from his original notes by the author, and was now offered, with the consent of the Secretary of the Smithsonian Institution, for publication by this Society, with the use of a number of wood-cuts already executed, and others drawn but not ready for use. On motion, the paper was referred to Dr. Leidy, Dr. Le Conte, and Dr. Bridges.

A memoir was presented for publication in the Transactions, by the Secretary, entitled "On the Formation of the Island of Sombrero, by Alexis A. Julien," and referred to a committee, consisting of Dr. Genth, Prof. Booth, and Mr. Lesley.

Mr. Briggs made a verbal communication of his views respecting the nature of the force by which petroleum is brought to the surface, regarding it as an intimate mechanical mixture of the gases, into which the petroleum spontaneously decomposes, with the petroleum fluid, like that which exists between the carbonic acid and the water in a soda fountain.

Mr. Lesley read a communication "On the Mythical Compounds of BAR," stating in substance the conclusions to which a study of the subject for nearly twenty years had led him, in the form of theses, which he did not purpose now to discuss at any length.

1. That the word BAR (with its isomorph BAL), and its mythical simple compounds B-BAR, T-BAR, K-BAR (with their isomorphs), and BAR-B, BAR-T, BAR-K (with their isomorphs), and other more complex compounds, partly mythical and partly vulgar, constitute the staple of that part of all language which was produced by and devoted to the use of the primæval (and mediæval) religionism of the human race.

2. That the word BAR was constructed and used to signify the trinity; not the personal triune deity of Athanasian Christianity, but the aboriginal and universal, druidic or arkite trinity, composed of three material objects, the *ship*, the *mountain*, and the *water*.

3. That the analogies which are observed by comparative philologists to exist between different languages, so far as concerns their vocabularies—analogies, considered by one class as organic, and, therefore, not necessarily congeneric, by a second class as accidental, and by a third class as proofs positive of a common origin—are in fact, and in the main, *ecclesiastical;* and constitute a distinct department of comparative philology, viz., the mythical, initiative, mystic, druidic, or arkite; purely invented, and propagated by a priestcraft, which penetrated, in course of ages, all nations.

4. That the organico-onomatopœic portion of language is susceptible of analysis and explanation on a few simple principles, involving, however, a reference to mysterious instincts. While the grammatico-organic portion is much more obscure as to its origin, although also subject to scientific classification.

5. That both the arkite or cabalistic portion of language, and the organic or spontaneous portion, are to be kept carefully separated, in comparative philology, from a third portion and the largest of all, consisting of the debris of the other two; being at once sedimentary, metamorphic, and pseudomorphic.

6. That it is by no means certain that the so-called monosyllabic languages have not reached that condition by a process of contraction, obviously going on in languages now spoken, like the French.

7. That a comparison of the most widely variant types of lan-

guages, e. x. the Chinese and the Latin, if made not directly, but by the intermediation of languages charged with the arkite or ecclesiastical element, e. x. the Australo-Polynesian group, will result in establishing a genuine and close alliance, the recognition of which has become a *sine quâ non* to the further progress of Comparative Philology.

8. That the explanation of the Alphabet will turn out to be not purely organic, nor merely hieroglyphic, but in part both; and under the domination, not of an unshackled, uninstructed, and irrepressible imagination, as most of the alphabet theories seem to postulate, but of an imagination highly cultivated, well-regulated, and subjected to a fixed mytho-philosophy, taught by initiation, and developed under cover of religious mystery.

9. That when the true alphabetic key is found, it can be applied to the discovery of the meaning of the whole architectural, geographical, zoological, botano-medical, heraldic, and genealogical nomenclatures; of all those portions of the languages of the mechanic arts, and marine life, which do not date lower than the sixteenth or seventeenth centuries; of the essentially formal terms used by the legal profession, and of the whole language of saga, folk-lore, fairy-tale, and nursery-rhyme literature. In a word, this Cabala, first exhibited in the alphabets of antiquity, penetrates all modern languages to such an extent, that the failures of comparative philologists to determine satisfactorily the most difficult questions of the science are due to their ignorance or contempt of it.

10. That a large proportion, if not the most of all diphthongs, are contractions, produced by dropping the middle consonant of a triradical dissyllable; such as *caer* from *cabar*, *taur* from *tabor;* and that the medial thus suppressed has been commonly, but not always, a labial.

11. That in perhaps a majority of cases, the long or double voyals η, ω, O, U, are contractions of the same diphthongal nature; while in other cases they represent the suppression of ρ, λ, r, l, final.

12. That the case- and gender-terminations S and M may be explained by the active and passive, or subjective and objective ideas attached to the two forms of the water-symbol. The Hebrew plural termination is explicable in the same way. And, in fact, that a certain portion of the doubtfully explained affixes and suffixes encountered by grammatical investigators are hierophantic or cabalistically alphabetic.

13. That the ship-symbol U, V, with its variants, the mountain-

symbol A, Λ, with its variants, and the water-symbol M, Σ, in its two postures, the horizontal and the vertical, constituted the original nucleus of the alphabet; to which were added subsequently compound symbols, such as X, Y, Θ, K, Ω, the intense or explicit water-symbol Ξ, and the organic letters φ, χ, ψ.

14. That the ship- and mountain-symbols were variously modified, and, for a curious but perfectly explainable reason, compounded, interfused, confused, and interchanged; whereas the water-symbol, for an equally plain reason, was kept simple and separate from the other two, and stands out clearly as the key element in all the compound symbols, whether literal or architectural.

15. That the unpronounceable AUM of the Brahmins is the mountain-ship-water symbol, pure and simple.

16. That the ♀ of the Egyptian hieroglyphics, the sign of life, or of divinity, or rather of regeneration to immortality, is the same ship-water-mountain symbol.

17. That the Egyptian box-capital and lotus-leaved-base column, was the architectural analogue of the same symbol; because classical and beautiful in the Taboric, Tauric, or Doric style of Greece; and exists still in the Norman column, with its box-capital surrounded by water-demons, and in all parts and details of the Gothic cathedral building, the whole of which is a nave or ship.

18. That the tonsure of initiation, the papal tiara, the ducal crown, the university cap, and many of the more curious female head-dresses practised by barbarous tribes, represent the same triple symbol.

19. That circumcism is not to be explained except as a practical way of rendering the arkite symbol permanent in that part of the human body adopted as primal by the phallic mythology; which, following arkism, accepted its phraseology, and applied its symbolik to a more philosophical train of ideas suggested by the generative powers of nature and the mysteries of child-birth.

20. That the serpent-worship mythology must be regarded as a one-sided arkism, due to an exaggerated reverence for the water powers, better represented by the serpent than by any other object of living nature. The serpent- and egg-symbol, especially in its form of the serpent, column and egg, or serpent, altar and bread, is perfectly arkite.

21. That the Yezidee, or devil-worship, was but a modification of ophism, and was represented in arkism by the worship of the crocodile, and other amphibious or marine monsters, by the legends of

Tannim, and the Typhon, and by the whole ceremonial of Sivaism, and was perpetuated in the bat-winged devil of Etruria, Japan, and the modern Miltonian orthodoxy. The half philosophical discussion of the evils flesh is heir to has produced Ahrimanism, Manachæism, and Dualism in general, in all ages; but the special symbolik of dæmon-worship or diabolism has, nevertheless, always been essentially and plainly arkite; as may be seen in the tales of the Genii, the Talmud, the Apocalypse of St. John, the formulæ of the necromancers, &c.

22. That many of the names given to the deity, and his attributes, to man and his qualities, to the insignia and the apparatus of church and state, are simple arkisms, and therefore common to many languages and different races of mankind.

23. That the religious controversies which arose with the gradual development of the religious phantasy, resulting in bloody wars and hereditary feuds, produced a confusion between the titles given to God and the devil, and between good and bad qualities, blessing and cursing, &c. So that the name of God for one tribe became that of a demon to another; and the whole sacred phraseology of one age became a senseless, obscene, diabolical jargon to the age which followed it. Yet the esseptial and original cabalism of the terms used in their double, opposite, or polar meanings, remained the same. The Hebrew ברך, for example, stood related to the BAR as closely after it had come to mean "curse," as when it meant "bless." Sacer was as much S-K-BAR in one of its meanings as in the other. The Tabu system of Polynesia is the double result of the same opposite relationships still maintained with the original תבה, from which we get Tub, Dove, David, the sacred Thebes, and a hundred other arkisms in every language of the earth.

24. That there are also certain words in all languages with opposite or polar meanings in a strictly *physical* sense, deducible, however, directly from the arkite symbolism of antiquity, as exhibited to former eyes; such as, in English alone, Barrow and Burrow, Top and Tub, Pile and Pail, Hill and Hole, Cap and Cup; the difference being marked by the artful use of vowels, according to a general law, which some have supposed organic or psychological, but which can be shown to be, in many instances at least, arkite.

25. That the first age of this arkite symbolism must be considered more remote than any history, because it preceded the invention of any kind of alphabet, and because its spirit presided over the erection of its earliest monuments. What was the precise nature of the

cataclysm from the remembrance of which its legendary ideas were fabricated, cannot now be discovered; but the supposition that some actual physical event called forth these ideas seems rendered necessary by what we know of the original rude nature and the unphilosophical mind of the race in its earlier stages of existence. It seems indeed just possible that the whole system took its rise in Egypt, and out of the annual phenomenon of the inundation of the Nile. At all events, this was the grandest natural commemoration of a deluge, and of a regeneration of life and hope for mankind; and here, in Egypt, took place the most complete and imposing development of the arkite symbolism—in the pyramids; in the propylæa with mountain sides, ark-like cornices above, and waving sands around their base; in sphinxes; Osiris-arks; death and resurrection ceremonials; and a thousand characteristic details equally significant.

26. That traces of arkism can be found abundantly throughout Africa, and in so pure a form, as to suggest to the geological antiquary the possible connection of its origin with the emergence of the Sahara.

27. That the bull-sphinxes and other monuments of Mesopotamia, the carpet and ring of the Flying Mithras of Persia, the lions attacking the bull, the arrowhead lying on the altar, &c., show arkism at home in that region of Asia.

28. That it pervaded India is equally evident from the details of the Hindoo mythology; from the Topes (תבה) and Pagodas with their uppermost story bulging into the form of a ship; from the Buddhistic history and the worship of Gaudama's foot; from a thousand local legends; the worship of the humpbacked cow; the Jain rites; ancestral worship and Ganges worship; from the dress and manners of the Rajpoots; the mysteries of Juggernaut; the supposed magical powers of barbers; and the whole life of the pariah races of the Peninsula.

29. That the present home of arkism is Thibet, where the system is in full life, complete in all parts, and developed to its highest pitch; that from this, as a living centre, it has radiated its ceremonial and its traditions to the farthest limits of the East; and that they can be studied in farther India, China, and Japan, Corea and Mongolia, the Polynesian Islands, California, Mexico, and Peru; explaining the Pagoda and its dragon, the Marai and its tabu, the shamanism of the hyperborean races, and the teocalli system of the new world.

30. That the Druidism of Europe is the western representative of

the lamaism of the East, continuing to exist and develop its infinitely prolific germs of variation and transmutation in the Greek and Roman Catholic churches, and in some of their Protestant offshoots. That the communion cup upon the altar, the pallium on the shoulders of the Cardinal, the Elizabethan collar around the neck of the Dompredigerat Berne, the baptism of the bell, the swinging of the censer, the name of the pulpit, and its normal box-form, mounted on a pillar and surrounded by quaint sculpture, are but instances of remaining arkism.

31. That the Legends of the Saints are to be rescued from contempt, and explained, only by reference to the spirit of arkism, which has thoroughly and energetically inspired the Church of Christ; inventing perpetually new dresses for the old symbols, and recommending them thereby to new classes of society, or to new sections of the heathen world. A perfect harmony can thus be established between the stories of the cloister and the sagas and folk-lore of the hearth; between the mythical St. Christopher and the equally mythical William Tell.

32. That Free-Masonry probably offers to its initiated another field for investigating living arkism. Its gavel and trowel are sacred symbols of the mountain; and its other insignia, the square and the compasses, are equally easy to read in the light of architectural mysticism. Its primæval grand-master, Solomon, the Man of the Cell, called himself the QELT (קהלת) or Cabalist.* Many branches of Free-Masonry have been produced in the course of ages, known by different names, and various in spirit, language, and rites, according to the temper of the times, the blood of the members, and the progress of ideas. But so far as their interior history has ever been revealed, the revelation has exposed the elements of arkism as the stuff of which originally their essence was composed. No phenomenon connected with the existence of man has excited more curiosity and speculation than the universal spread of not only the spirit, but the language of Free-Masonry around the world. It can only be explained by reference to the simplicity of its formularies, and their preservation from the remotest antiquity, as modern representatives of primæval arkism.

* QEL, קהל, κυκλοσις, kirk, church, as well as the verbs which correspond to them and from which they are commonly supposed to be derived, viz., קהל, καλεω, select, collect, &c., find their explanation in the Arkite Cabala.

33. So wide a generalization of facts from all departments of history in the past, and human life in the present, centred at so small a group as that which has been described above, under the name of the arkite symbol of the mountain, ship, and water, will necessarily incur the charge of one-sidedness. The theory will be said to attempt too much, to run itself into the ground, to break down with its own weight. It will find arrayed against itself other theories of primæval history, laboriously invented by the best thinkers of the last hundred years, each claiming to explain the rise and development of human thought and culture, as well as most of the anomalous and eccentric, fantastic and absurd, misapplications of men's views of the supernatural, and of nature. Of no part of science is it a truer saying than of this, that no theory can be true that does not accept, ally, and illustrate, all that is true in all other theories; embodying their generalizations within its own, and differing from them only in the superior expansiveness of its field of vision. Modern geology is neither Huttonism nor Wernerism, but an eclectic combination of both. Sociology, as now best taught, recognizes the justness of every form of government in its natural place. The science of physics is a compound precipitate from the relation of the most prosy parts of materialistic natural-history, and the finest transcendental or metaphysical notions respecting essence, and the mysterious forces of the entire universe. Even theology is being stimulated from its sleep of ages by stimulants administered by unbelieving savans. Isolation is no longer possible for the investigator; and his theories must be in good society, or be tabooed.

34. Archæology has been based exclusively on Astrology by some of its best writers. Undoubtedly there is a department of astronomical archæology; and the genius and learning displayed in such a master-piece as Dupuis' great work were far from being thrown away. On the contrary, it is as much a cabinet of new-discovered facts and truths, as Boucher des Perthes' Celtic Remains, or Tyndall's Lectures on Heat. But it does not follow from all the wonderful coincidences between mythologies and the phenomena of the sky, that the aboriginal mythology was astronomical. Man's eyes were early dazzled by the light of the sun, and his heart melted by the beauty of the moon; but an earlier worship may have existed for his soul, and centuries of intellectual development may have been needed before the order of the stars could take so strong a hold upon his imagination, as to subjugate his reverence, and systematize his hopes and fears into the Mithraic and Sabæan forms. Some wider synthesis must in-

clude Dupuis'. The very nomenclature of sun- and planet-worship, requires an older worship for its explanation; so does its architecture; so does its symbolism. The ring, the bird's tail, the carpet of Mithras, find no account of themselves in astronomy. Fire-worship was evidently adopted and carried like a child by an older mountain-worship. If the central triliths of Stonehenge have their tops cut down to the plane of the ecliptic, the central sacrificial stone, sloped for the draining off of human blood, is a structure suggestive of quite a different system,—that of the arkite loggan and ambrose stones of the whole druid world. Supposing Turner's views respecting the great pyramid to have been made mathematically certain by the late paper of the Astronomer Royal of Scotland, Turner himself insists that the great pyramid differs from all other pyramids, in Egypt and elsewhere, in this very fact, that it alone is astronomical; the rest must give some other account of themselves. Arkism embraces and explains astronomical archæology, but the latter cannot explain the former.

35. Then there is the Phallic system of Kanne, and all the learned writers of that school. A theory of antiquity not to be despised—a grand summary of indubitable facts—it has a philosophical basis to stand upon. It has immense resources in philology. It is written with the freest and coarsest hand on the monuments of east and west. It explains, and is explained by, the experiences of monastic life. It appeals for justification, in fact, to the strongest of all the energies of nature, both physical and spiritual, when it affirms that the first astonishment man felt was at himself when he began to cohabit with woman; and the second, at the birth of his first child; that thus all worship sprang from love, and all its symbols from the organs of reproduction; replaced afterwards by such objects of nature as mountains, caverns, and seas, for grandeur's sake. If, however, the nomenclature, the architecture, and the ritual of Phallism can be shown to have had an anterior existence, unmodified by the gross sentiments of animal love, and to be explainable on a hypothesis, not personal to the individual man, but common to mankind, then the Phallic theory, like the astronomical, must take a secondary rank, and be accepted only for what it is worth within its just limits; while its formal origin and outer development will be referable to that older and more general arkism, whose language it had adopted, whose symbols it had modified, whose truths it had degraded, whose pure and simple worship it had debased and defiled, but still continued to illustrate.

36. The Ophite theory is considered, by the authors of such books as the "Serpent Symbol," all sufficient to account for the prehistoric religious history of man. This seems to be a most presumptuous supposition. The theory has to do with no grand event in history, which might be supposed to have made an indelible impression upon the life of mankind; nor with any general idea of the sublime or terrible, germain to worship; nor to any master sentiment of the human heart,—for fear is not so strong as love, nor so instructive as curiosity, nor so inventive as taste. The theory involves a mere classification of one kind of archæological facts, requiring the simplest treatment, and barren of all results but one, namely, a certain addition to the mass of evidence, otherwise collected, that some mysterious arkite intercourse has existence between all the known races of the world. Beyond this, Ophism has no story to tell; and instead of elucidating antiquity, adds to its confused obscurity. But Ophism is one of the great facts of history, notwithstanding; and enters not only largely but naturally into the composition of the arkite theory, which fully unfolds it, suggesting for its existence a new and satisfactory cause, and explaining all its forms and variations perfectly.

37. Then there is the great archæological problem of Devil-worship, for so many portions of mankind, the terrors of shamanism, the darker or fearful side of fetischism, all so nearly allied to serpent-worship, and all so nearly explainable by reference merely to the limitations of human will and human happiness, but none of them quite so. What shall be done with the unexplained residuum? Archæology claims it; but which archæological theory shall take charge of it? Certainly none of these theories of departments, departmental theories,—we need the new name,—already alluded to. No. To learn the language of Fear-worship, we must go back to the very beginning; to some age of weakness, calamity, and fright; to some irruption of wild beasts, or conflagration, or deluge; to some event so overwhelming that it could impress no less than all mankind, for a time no less than all the ages, the memory of which would be a simple figure of destruction and salvation combined, the symbol of which would be the intertwined names of God and the Devil. In the mountain and the ship, which rescued mankind from destruction in that event, we have the explanation of the origin of all Phallism and Egg-worship. In the waters which came so near destroying him, we have the explanation of the origin of all Ophism and Devil-worship. Both were made ornate in the tasteful idolatry of Greece, scientific on the clear-

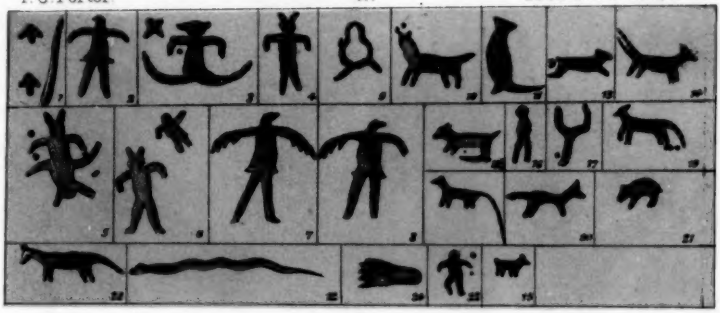
eyed mountain-land of Persia, and spiritual among the justice-loving seers of Palestine. Before arkism, of course, was universal fetischism, like a great chaos, without law, or any method of self-expression; and after arkism, came all forms of thought and feeling possible for man to invent, but all budding from this Yggdrasil, and bearing flowers and fruit after the pattern of its undying life.

38. It is not, therefore, in violation of the great canon of modern science, but in obedience to it, that the arkite theory sets up its claims to universality.

39. What the great event was which so impressed the worshipful mind of the human race, or whether the chronic relationships of mankind in the earlier stages of their existence to mountains, or firm land in general, to boats, rafts, or stationary crannoges, and to all waters in general, may not compensate for the doubt which physical science cannot help throwing over the story of a Noachian deluge,—it will be hard to demonstrate. Geological investigation has as yet discovered no traces of a real event, such as is described in Mosaic and other records of the barbarous ages of the world. That science, however, has long taught the alternate submergence and emergence of dry land; and all its latest teachings are of the extreme antiquity of human life upon the earth, and of man's contemporaneous existence with other now extinct animals, during a glacial epoch, involving probably great floods, and opening into the comparatively modern age at the beginning of which men lived upon the waters, instead of on the land. The Arkite theory has nothing to say on these matters. It starts from a given point, the already established worship of the mountain, ship, and flood, without explaining how this worship was begotten; only denying that it was developed intellectually out of Fetischism, Ophism, Mithraism, Phallism, or any other known mythology; and affirming on the contrary, that it explains and embraces them.

Pending nominations, Nos. 534 to 539, and new nomination 540, were read.

And the Society was adjourned.



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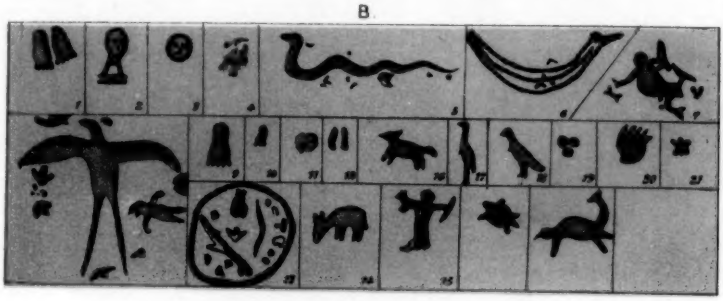

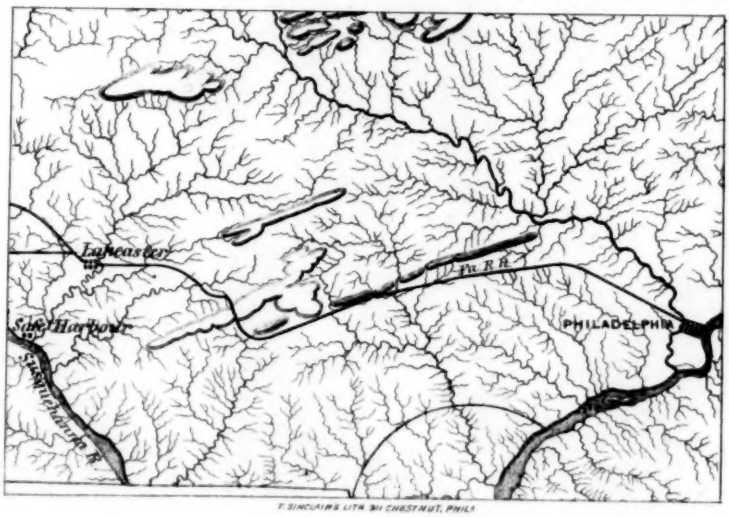

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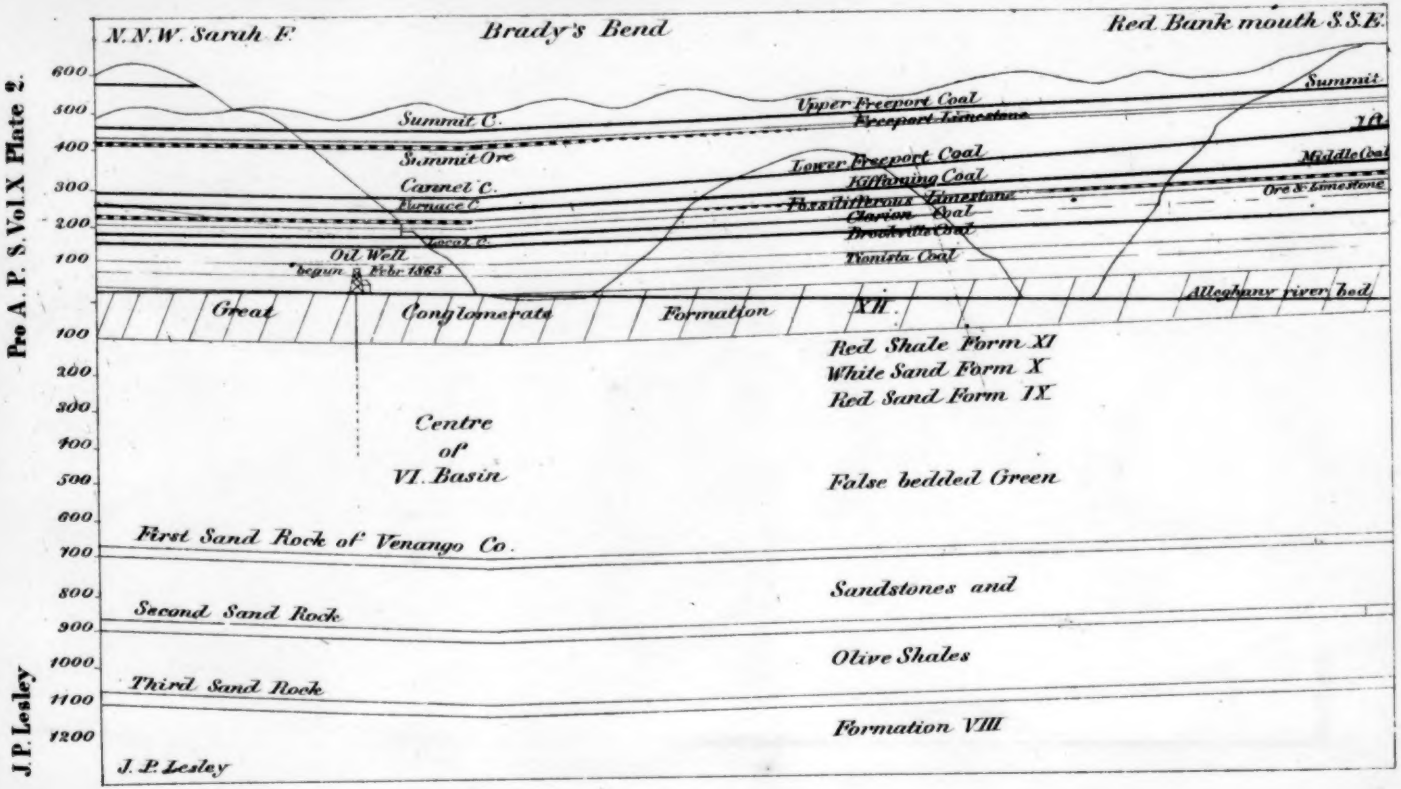
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N.N.W. Sarah F.
Brady's Bend
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Summit C.
Summit Ore
Cannel C.
Pervance C.
Local C.
Oil Well
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Upper Freeport Coal
Freeport Limestone
Lower Freeport Coal
Kittanning Coal
Fluxiliferous Limestone
Clarion Coal
Brookville Coal
Mantata Coal
Summit
Middle Coal
Ore & Limestone
Allegheny river bed
Great
Conglomerate
Formation
XII.
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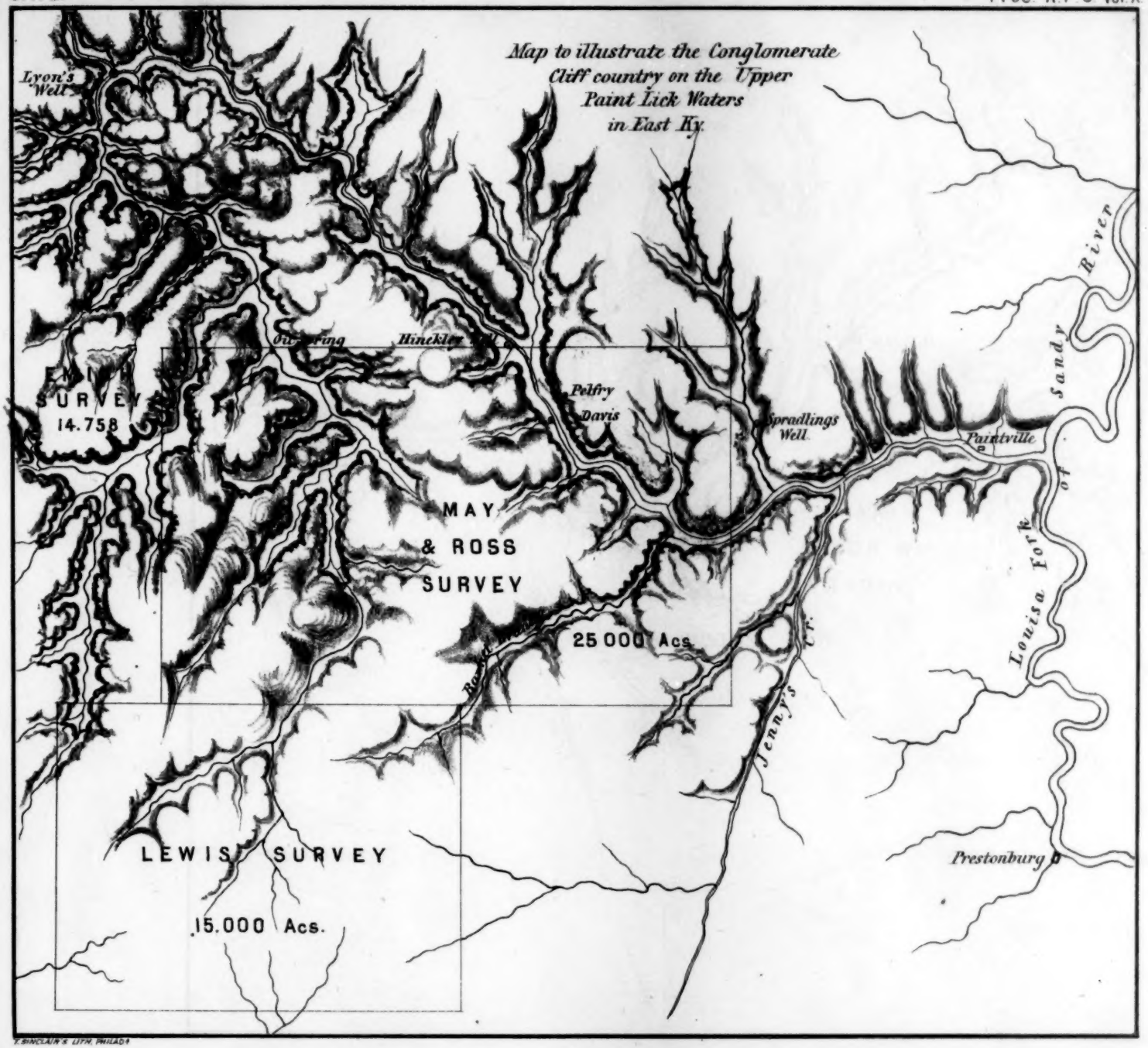
Red Shale Form XI
White Sand Form X
Red Sand Form IX
Centre
of
VI. Basin
False bedded Green
First Sand Rock of Venango Co.
Sandstones and
Second Sand Rock
Olive Shales
Third Sand Rock
Formation VIII
J. P. Lesley
J. P. Lesley



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